The Impact of Risk Factors and Regulatory Change in the Returns of European Energy Utilities

by

Daniel James Tulloch

Thesis submitted for the degree of Doctor of Philosophy
Department of Accountancy & Finance
School of Commerce
University of Otago, Dunedin
New Zealand

June 2016

© This copy of the thesis has been supplied on condition that anyone who consults it is understood to recognise that its copyright rests with the author and that no quotation from the thesis, nor any information derived there from, may be published without the appropriate citation or the author's prior, written consent

ABSTRACT

This thesis examines the risk factors affecting the returns of European energy utilities. Since 1996, European energy utilities have been impacted by changing commodity dynamics and European Union (EU) -induced policy challenges, including liberalisation and environmental objectives, which are materially affecting financial return. The EU's drive to create a single European energy market and the 'greening' of energy supply have been described as the world's most extensive cross-border reforms of energy networks and operating structure. Commentators suggest that these changes have resulted in a €500 billion loss in market value. Thus, understanding the risk factors and impact of policy on the financial return and valuation of European energy utilities is of utmost importance. This thesis represents the most comprehensive analysis of these changes to date, employing a sample of 88 energy utilities and 54 regulatory changes between 1996 and 2013. The thesis examines how returns are impacted by: 1) stock market and commodity risk premia, 2) the time-varying nature of the risk premia and 3) liberalisation and decarbonisation objectives on the sector.

More specifically, Chapter 4 develops an asset pricing model which is superior at explaining variation in energy utility returns compared with existing specifications. An inter-sectoral analysis shows that energy utilities' returns are distinct to other sectors, including the oil & gas sector. The results also show inter-temporal variability in parameters. Chapter 5 addresses existing criticisms of asset pricing models, making adaptations to overcome poor performance at the sector level. The chapter also implements deductive and inductive structural break point tests, identifying significant break points in parameters and better isolates the unsystematic, firm-specific component of returns. Chapter 6 utilises the comprehensive asset pricing model developed in Chapter 5 to implement an event study approach surrounding key stages of the ordinary legislative procedure, examining the timing of market reaction and information incorporation. Further, Chapter 6 also explores how returns are impacted by four major policy streams, namely: Internal Energy Market, Energy Efficiency, Renewable Energies and Security of Supply streams.

The findings are multiple and appeal to academics and policy-makers alike. The results show that energy utilities are increasingly exposed to market and commodity risk factors through time, with standard finance risk factors having a greater impact than commodities. The results also show previously undocumented heterogeneous return profiles across different utilities, subject to significant structural breaks. Overall, the Internal Energy Market and Energy Efficiency streams have a cross-sectional negative impact on energy sector returns and at an early stage of the legislative procedure, thereby affect the sectors' ability to raise the estimated €2.2 trillion investment capital needed to transition to a 'smart', decarbonised energy system. The Renewable Energies and Security of Supply streams have a limited impact on sector returns.

ACKNOWLEDGEMENTS

I would like to thank my current supervisors Dr. Ivan Diaz-Rainey, Associate Prof. I.M. Premachandra and Prof. George Benwell for their guidance and ongoing support over the years. I started my PhD at the University of East Anglia (UEA), Norwich, with Dr. Diaz-Rainey and transferred to the University of Otago, Dunedin, following Dr. Diaz-Rainey's move to New Zealand. Accordingly, there are a large number of individuals I would like to thank.

I would like to thank the Norwich Business School for offering me a position on their PhD program and a fees waiver during my time there. Particularly, I would like to thank two of my former supervisors, Prof. Naresh Pandit and Prof. Peter Moffatt, for their support. I would also like to thank the former Head of Department, Prof. Nikolaos Tzokas, and the postgraduate research director, Dr. Hing Kai Chan, for accepting me onto the PhD program and facilitating my transfer to the University of Otago, respectively. In New Zealand, I would like to thank the University of Otago, particularly Prof. George Benwell and Prof. Colin Campbell-Hunt, for their support and the 'Deans Scholarship' offered to me on the PhD program of the Department of Accountancy & Finance.

I'm grateful for the helpful comments received during conference presentations and seminars, particularly: my UEA transfer panel (Norwich, 2011), the UK Energy Research Centre Sparks Symposium (Kensington, 2011), the UEA Doctoral Colloquium (Norwich, 2011), the 9th International Conference for the European Energy Market (Florence, 2012), The 25th annual IAEE international conference (Perth, 2012), the 17th and 19th New Zealand Finance Colloquiums (Dunedin, 2013; Hamilton, 2015), the Otago Energy Research Centre Symposium (Dunedin, 2014) and the Department of Accountancy & Finance Departmental Seminar Series (Dunedin, 2013, 2014 and 2015). Also, I would like to extend my gratitude to the discussants of my paper at the 19th New Zealand Finance Colloquium, Prof. Henk Berkman and Prof. Ron Bird, for helpful comments. I am also thankful for the valuable comments and suggestions from Prof. David Lont, Prof. Timothy Falcon Crack, Prof. Jin Zhang, Dr. Eric Tan, Dr. Numan Ulku, Dr. Duminda Kuruppuarachchi and Dr. Stephen Kean during Department of Accountancy & Finance research seminars. Further, I thank three examiners for their helpful comments during the PhD examination process.

I would also like to thank my friends and family for being so patient with me during my PhD, particularly my parents, brother and sisters. Thank you for your support over the years. I would like to thank all my grandparents. I know you would be, and are, proud of what I have achieved and I thank you for the parents and family I have today. Finally, a special thanks to my girlfriend, Manda, for her ongoing moral support doing my thesis.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

Abbreviation	Description
ACER	Agency for the Cooperation of Energy Regulators
ADF	Augmented Dickey-Fuller
AF	Analytical focus/foci
AFFM	Augmented four-factor model
AR	Abnormal return
BE/ME	Book-to-market ratio
CAARs	Cumulative average abnormal returns
CAPM	Capital Asset Pricing Model
DSO	Distribution system operators
ENTSO-E	European Network of Transmission System Operators for Electricity
ENTSO-G	European Network of Transmission System Operators for Gas
ERGEG	European Regulatory Group for Electricity and Gas
EU	European Union
EU ETS	European Union Emissions Trading Scheme
EUA	European Union Allowance
EUC	Eurozone crisis (2010 to 2011)
FVU	Fraction of variance unexplained
GFC	Global financial crisis (2007 to 2009)
GHG	Greenhouse gas
HAC	Heteroskedasticity and autocorrelation
HML	Value risk factor/premium (high- minus low-BE/ME)
LHS	Left-hand side
OLS	Ordinary least squares
RHS	Right-hand side
RQ	Research questions(s)
SMB	Size risk factor/premium (small minus big)
SIC	Standard Industrial Classification
SSR	Sum of squared residuals
TSO	Transmission system operators
UMD	Momentum risk factor/premium (upper minus down momentum)
VIF	Variance inflation factor

CHAPTER 1

THESIS INTRODUCTION

1.1 Introduction to Thesis

This thesis contributes to a better understanding of how risk factors are affecting the returns of European energy utilities. Since 1996, European energy utilities have been impacted by changing commodity market dynamics and European Union (EU) -induced policy challenges which are materially affecting financial return. The EU's drive to create a single European energy market and the 'greening' of energy supply have been described as the most extensive cross-border reforms of energy networks and operating structure in the world (Jamasb and Pollitt, 2005). This thesis represents the most comprehensive analysis of these changes to date by employing a sample of 88 energy utilities and 54 regulatory changes between 1996 and 2013. Using this broad sample and list of regulatory events, the thesis focuses on three central empirical chapters, which can be further divided into research questions (RQ) and analytical foci (AF). The three chapters are as follows:

1) **Risk factors in energy utility returns: An Augmented-Four-Factor Model (AFFM).** This chapter develops a 'global' asset pricing model for European energy utilities by incorporating stock market, term premium and commodity risk factors. This global model allows for comparisons across sectors and to explore how these risk factors have evolved over time, answering four research questions (RQs):
   - RQ1: To what extent do commodity price changes impact the returns in the European energy utility sector?
   - RQ2: Could stock-market risk factors better explain the variation in energy utilities' returns?
   - RQ3: Do the impacts reflect market-wide conditions or the sector-specific relationships between returns and risk premia?
   - RQ4: Are these risk premia time-varying?
2) **Refining the AFFM and exploring within-sector heterogeneity.** This chapter refines the AFFM in a number of ways, including calculating sector level stock market risk factors, deriving the 'local' AFFM, which has greater explanatory power. Further, the chapter explores within sector heterogeneity, allowing comparisons between big and small utilities and between electricity, gas and multi-

utilities. The chapter also tests for structural breaks in risk premia, and improves the isolation of the firm-specific component of returns. This chapter has four analytical foci (AF):

  - AF1: Refining the global AFFM (above) by calculating stock market risk factors at sector level, creating a local AFFM.
  - AF2: Applying the local AFFM to sub-group portfolios of European utilities so as to explore within-sector heterogeneity.
  - AF3: Applying inductive rather than deductive structural break point tests.
  - AF4: Better isolating the firm-specific component of returns.

3) **The impact of regulatory changes on energy utility returns.** This chapter explores the impact of regulatory changes on European energy utilities on two levels. First, it explores market reaction surrounding key stages of a lengthy and complex legislative process. Second, it explores the impact of four distinct restructuring streams on energy sector returns, including the: Internal Energy Market, Energy Efficiency, Renewable Energies and Security of Supply streams. Accordingly, this chapter answers two research questions (RQs):

  - RQ1: Examining the timing of market reaction surrounding key stages of the legislative procedure.
  - RQ2: Measuring the impact of the four distinct restructuring streams.

This thesis makes an empirical contribution to the energy economics literature. While energy utilities are able, and expected, to hedge against commodity risk, the impact of regulatory changes can have dramatic implications for the operating environment of energy utilities. An accurate understanding of the financial return of European utilities is yet to be provided, since the energy economics literature relies on antiquated asset pricing models. The purpose of this thesis is to improve the asset pricing model to provide precise estimates of the impact of various risk factors and regulatory changes on the sector's financial return and valuation. As a corollary, this thesis provides a flexible tool which can be adapted to other sectors, since it suggests a method of more accurately examining within-sector heterogeneity, time-varying risk premia and isolating the firm-specific component of returns for any sector. Academics, practitioners and policy-makers alike can benefit from improved equilibrium asset pricing functions and isolation of the firm-specific component of returns. In turn, the improved asset pricing model can be used in a variety of ways, including: 1) portfolio selection, 2) evaluating portfolio performance, 3) estimating cost of capital and 4) measuring abnormal return in event studies.

Traditionally, European energy supply was based on national and regional markets with vertically integrated companies that could produce, transmit and distribute energy to nearby consumers with natural, regional monopolies. Since 1987, the EU has begun to make progress towards greater European integration, allowing the free movement of goods, persons, services and capital across European borders. The overall objective was to increase transnational competition within the EU, thereby exposing inefficiencies in firm operations and slowly phasing out inefficient firms. Consequently, there have been a large number of legislative acts establishing common rules for a single European internal market for energy, replacing the national- and regional-based structures for energy supply (Newbery, 2002, Jamasb and Pollitt, 2005, Green, 2006). This gradual approach was designed to enable the sector to adjust in a flexible and orderly manner to its new competitive environment.

The removal of national barriers created an international market where energy utilities can compete on price, services and market share. In a regulated system, the demand for energy, such as electricity, was relatively easy to predict as utilities had exclusive rights to regions. When faced with competition, utilities must accommodate the additional challenge of determining their energy supply based on energy demand and competitors' energy supplies. In addition, the energy sector has been exposed to a number of environmental objectives aimed at reducing carbon emissions through policy and market mechanisms, such as the European Union Emissions Trading Scheme (EU ETS).

Could energy market liberalisation and environmental objectives have unintended consequences with respect to operational and financial return? Figure 1.1 shows that the STOXX® 600 Europe Utilities index, a proxy for the largest European energy utilities, fell by -55% between December 2007 and June 2012. In a recent report entitled 'How to lose half a trillion euros', *The Economist* newspaper suggests the decline in market capitalisation equalled €500 billion – a fall in value greater than bank losses over the same period (The Economist, 2013b). Some utilities saw share prices fall by three-quarters and income fall by more than a third since 2010, coupled with a change in dividend policy. Figure 1.2 shows the yields on some energy stocks, which previously tracked German 10-year bonds, have increased over time – some in excess of 10%. The higher yields imply an increase in the cost of capital required by investors for holding energy utility stocks.

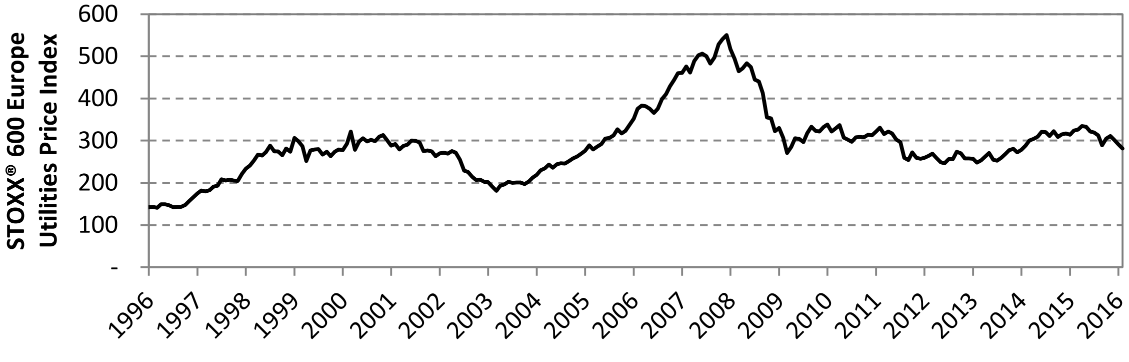


FIGURE 1.1: STOXX® 600 EUROPE UTILITIES INDEX

This figure presents the STOXX® 600 Europe Utilities index between January 1996 and March 2016. Data from STOXX®.

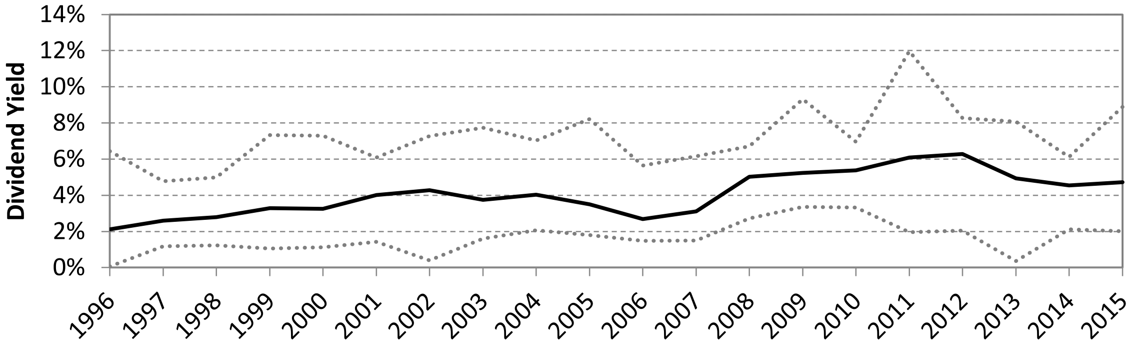


FIGURE 1.2: DIVIDEND YIELDS ON EUROPEAN ENERGY UTILITIES

This figure iilustrates the dividend yield on the 26 constituent stocks of the STOXX® 600 Europe Utilities index between fiscal years 1996 and 2015. The solid line represents the median across all companies, the dashed lines represent the 95% confidence intervals. Data sourced from S&P Capital IQ.

Investment incentives are perceived to be a growing problem in many countries (Joskow, 2008). Access to private investment is essential to meet the sector’s investment needs. The International Energy Agency (IEA) projects up to $2.2 trillion of total power sector investment is needed in the EU between 2014 and 2035 (IEA, 2014). Of this value, $1.6 trillion is allocated for new generation capacity, three-quarters of which will be invested in renewables, increasing the proportion of renewables in energy generation from 24% in 2012 to 44% by 2035. This is a concern since energy sector investment is increasingly being shaped by government policy measures and incentives, rather than price signals from competitive markets (IEA, 2014, Robinson, 2015). A stable and sound market framework that reduces uncertainty, especially political uncertainty, encourages long-term investment (Cramton and Ockenfels, 2012). Yet, some argue that the current regulatory and market framework can conflict with the policy objectives of decarbonisation, competitiveness and security of supply. As a result, many private investors consider the energy sector “non-investment grade” (FTI-CL Energy, 2015). In this respect, the thesis highlights a tension between liberalisation objectives and the objectives demanding that the energy sector transition to a low-carbon, renewables-intensive system through capital market assisted investment.

Turning to the academic context of the thesis, there is a body of literature which focuses on the effects of deregulation and liberalisation on company performance, both empirically and from a policy perspective (Kane and Unal, 1988, Beneish, 1991, Megginson et al., 1994, Gual, 1999, Nwaeze, 2000, Newbery, 2002, Jamasb and Pollitt, 2005, Green, 2006). Further, there is a plethora of empirical evidence regarding the role of stock market risk factors, term premium and commodities on the valuation of equities (Fama and French, 1993, Jegadeesh and Titman, 1993, Carhart, 1997, Faff and Brailsford, 1999, Sadorsky, 2001, El-Sharif et al., 2005, Boyer and Filion, 2007, Oberndorfer, 2009a, Ramos and Veiga, 2011, Koch and Bassen, 2013).

Nevertheless, there is limited research which combines the two bodies of literature to identify a comprehensive list of risk factors for the European energy utility sector, which also accounts for issues such as survivorship bias and the intricacies of the European legislative process. For instance, Oberndorfer (2009a) and Koch and Bassen (2013) respectively examine oil and carbon risk exposure for European energy utilities. Both papers use small samples of 22 and 20 utilities, respectively, and fail to control for survivorship bias. While Koch and Bassen (2013) explore the impact of carbon price risk, neither paper examines the impact of liberalisation objectives on utility returns. Further, they do not account for standard finance risk factors such as firm size, book-to-market ratio and momentum (Fama and French, 1993, Carhart, 1997). Both El-Sharif et al. (2005) and Oberndorfer (2009a) have identified the incorporation of conventional finance risk factors into the asset pricing of energy utilities as a valuable avenue for further research. This thesis fills this niche. More generally, energy utilities are often annexed within the oil & gas sector in asset pricing tests, where risk factors regarding the latter are assumed true for the former. For instance, both Oberndorfer (2009a) and Koch and Bassen (2013) draw much of their literature from the oil & gas literature. In reality, nuances between the energy utility sector and the oil & gas sector warrant independent analysis. Therefore, this thesis enhances academic understanding of the European energy sector by undertaking the following enhancements to the existing literature:

- Constructing the largest sample of 88 European energy utilities, across electricity and natural gas operations, which controls for survivorship bias.
- Developing a sector-specific asset pricing model, which is superior in capturing variation in sector returns and isolating the firm-specific component of returns by incorporating standard finance risk factors into asset pricing models.
- Conducting the most thorough and full-scale asset pricing test to date of risk premia in average sector returns and identifying within-sector heterogeneity.

The test also examines the time-varying nature of the risk premia through inter-temporal analysis and inductive structural break point tests.

- Identifying a broad range of regulatory changes impacting the European energy utility sector to date and classifying them into four policy streams, namely: *Internal Energy Market*, *Energy Efficiency*, *Renewable Energies* and *Security of Supply*.
- Using the novel asset pricing model in an event study setting to isolate the impact of regulatory changes on the energy sector, both in terms of the timing (i.e. when investors incorporate information from the EU legislative process) and in terms of policy streams so as to determine which policies are having the biggest impact on returns.

The rest of this chapter expands on the introduction to the thesis. Section 1.2 provides the motivation for the thesis. Section 1.3 outlines the thesis' research objectives. Section 1.4 presents the central and chapter-specific hypotheses of the thesis. Section 1.5 lists the originality and contributions of the thesis. Finally, Section 1.6 presents the organisation of the thesis.

1.2 Motivation and Policy Background

The motivation for this thesis is primarily empirical, where the main objective of Chapters 4 and 5 is to develop a single asset pricing model for the European energy utility sector from a finance perspective. Since the mid-1990s, there has been a divergence between the *energy economics* and *finance* literatures. Chapter 3 of this thesis will show that the finance literature is primarily concerned with searching for market anomalies which explain average returns across a diverse range of stocks. In contrast, the energy economics literature has focused on identifying macroeconomic variables which were argued to be systematically priced into stocks. The two bodies of literature are rarely reintegrated and the stock market risk factors are largely ignored in the energy economics literature. The examination of European energy utilities is limited to two key papers, namely, Oberndorfer (2009a) and Koch and Bassen (2013). However, the two papers have a number of shortcomings, including: small sample bias, short time series, and poor selection of macroeconomic variables. A well specified asset pricing model and its role in determining the cost of capital is an important topic in the finance literature from a risk, capital allocation and regulatory perspective. Equally, a misspecified model creates distortions in these areas. This thesis improves on the existing research methods by creating an asset pricing model which more closely predicts changes in equity value to better understand how risk factors are affecting the returns of European energy utilities.

The novel asset pricing model is also used in Chapter 6 to examine the impact of new legislation on the value of energy utilities, and the implications on the ability to raise private capital to facilitate a transition towards a low-carbon energy grid. European energy utilities have been the subject of intense debate about perceived excess accounting returns and oligopoly power in the European energy sector. It is argued that these energy companies are making excess returns at the expense of the consumers, but often the risk borne by the energy utility companies is overlooked.

The press, such as The Economist (2013a; 2013b; 2013c; 2015) and The BBC (2013), has argued that renewable energy objectives have negatively impacted the valuation of the EU energy utility sector. For example, the Economist (2013b) suggests that the growing share of renewables, and the policies that support them, have destabilised the European energy grid, depressed wholesale prices, reduced reliability, and imposed undue and unnecessary costs. The report proved popular and is being increasingly cited by a range of stakeholders, including: academia (Heffron and Nuttall, 2014, Osorio and van Ackere, 2014, Hildmann et al., 2015, Robinson, 2015, Corsatea et al., 2016), think-tanks (Caldecott and Robins, 2014, Friends of the Earth, 2014, McKinsey & Company, 2014, Sussex Energy Group, 2015, Gray, 2015), and energy literature (Elkington et al., 2014, Lacalle and Parrilla, 2015). This thesis proves that in this respect, the press is subject to focalism as other European regulatory objectives have a greater impact but are mostly ignored.

This thesis objectively quantifies whether there has been some fundamental shift in the operating or regulatory environment of energy utilities that may explain their altered returns. In particular, the liberalisation and decarbonisation[1] of the energy sector have been key policy issues at the EU-level over the last few decades, and they remain central to EU policy agendas today. The European electricity and gas sectors have undergone the world's most extensive cross-border reforms of energy networks and operating structure (Jamasb and Pollitt, 2005). The objectives of restructuring were to liberalise and decarbonise the energy sector, fostering a shift towards national and international competition, and reducing sector-wide carbon emissions.

The shift towards open competition removed traditional regional markets which protected utilities from the profit effects of cost and demand shocks (Nwaeze, 2000). The perception of the market is that these regulatory changes have negatively impacted the energy

---

[1] Decarbonisation is discussed under the heading of environmental objectives.

sector. The risks associated with open competition from sector liberalisation and the use of new technologies from sector decarbonisation have led to debates on the economic merits of restructuring the sector, particularly given the impact these reforms have had on the valuation and financial return of energy utilities. Further, EU utilities have also been subject to a range of legislations related to enhancing security of supply. This naturally leads to the question: how have these regulatory changes impacted the returns of EU energy utilities? This question matters as the EU has 503 million citizens[2] and collectively represents the largest economy in the world (measured in nominal GDP).[3] To place this perception in context requires understanding the impact of each restructuring objective. Accordingly, the following sections address the motivations for examining liberalisation and environmental objectives independently.

1.2.1 The Impact of Liberalisation

The privatisation and liberalisation of the European energy utility sector introduces a strong profit-motive to operations, where utilities are expected to compete on marginal cost to secure customers and generate revenue (Gual, 1999, Jamasb and Pollitt, 2005). A major objective of deregulation was to increase efficiency in the production, transmission, and distribution of electricity by phasing out inefficient firms through competition,[4] which was expected to also lead to energy lower prices[5] (Green and Newbery, 1992, von der Fehr et al., 1993, Newbery, 1998) and increase performance (Kumbhakar et al., 2001). Literature across multiple sectors argues that deregulation and liberalisation can have negative short-term impacts on firms due to high financial costs of reorganisation, re-training, increasing brand awareness and cutting unit costs to gain greater market share (Gual, 1999, Nwaeze, 2000, Delmas and Tokat, 2005). A company that is entering the deregulated market with relatively higher costs will suffer more adverse effects from deregulation. As cost, supply and demand fluctuate in a competitive environment, the financial burden is absorbed by energy utilities, resulting in lower profit margins or volatile revenue streams.

These changes alter investors' assessment of the energy utilities. As outlined by Schwert (1981), as investors anticipate changes to the infrastructure of a market, the perceived changes in future cash flows will affect today's pricing of an asset. Assuming rationality, if

---

[2] 2014 data extracted from EUROPA: http://europa.eu/about-eu/facts-figures/living/index_en.htm

[3] 2014 data extracted from EUROPA: http://europa.eu/about-eu/facts-figures/economy/index_en.htm and http://ec.europa.eu/trade/policy/eu-position-in-world-trade/

[4] Directive 1996/92/EC

[5] This typically refers to wholesale prices, which determines remuneration to utilities, through equilibrium analysis and assuming fair auction rules. Retail prices, which are available to consumers, may be subject to taxes and levies which can alter final energy price.

market reform is perceived positively (negatively) in the market, then additional benefits (detriments) will be incorporated into the company's productive assets and the investor can expect to gain (lose) economic rents (Schwert, 1981, MacKinlay, 1997). The changing nature of energy utility asset pricing as a result of restructuring has put into question utilities' role as a steady, reliable and defensive investment asset. Investors are expecting greater compensation for holding energy assets and taking a more active role in trading into and out of energy utilities positions in response to regulatory changes.

Any increase in earnings variability reduces the ability of investors to predict the future cash flows of the company and future cash flow from dividends, and therefore must affect the market value of financial assets (Nwaeze, 2000). This increased variability makes financial planning difficult (Merton, 1973, Lundblad, 2007). Highly variable stocks can mean huge losses and gains for an investor, and therefore greater uncertainty, thereby becoming the classic risk-return trade-off (Merton, 1973, Lundblad, 2007, Hajizadeh et al., 2012).

Most critically, it is difficult for underwriters to value companies characterised by high uncertainty; therefore, it is difficult for companies to raise capital through public offerings (Lowry et al., 2010). Furthermore, the decline in government intervention and increased privatisation of sectors limits the possibility of reactivating large-scale investment projects (Söderholm, 1998). This, in turn, can lead to underinvestment in the energy utility infrastructure. The average cost of equity capital for energy firms increases as stakeholders demand higher rates of return for the level of risk borne (Sharpe, 1964, Schwert, 1981, Nwaeze, 2000).

There is, however, the potential that market liberalisation can have some beneficial effect on European energy utility companies. In regulated markets, regional electricity demand and the ability of the company to expand must depend on the population size and economic growth of the surrounding area. By removing national barriers, European energy utility companies are able to expand operations, enter new markets and acquire new consumers. The new environment brought about by liberalisation promotes a more competitive environment and can increase performance (Kumbhakar et al., 2001). However, privatised European utilities must normally yield a higher return on capital, as they can no longer rely on public budgets, which typically have lower interest cost (Söderholm, 1998). The withdrawal of government-backed debt forces privatised firms to access public equity markets (Megginson et al., 1994). Again, this implies an increased cost of capital for European energy utilities, making equity a relatively expensive source of capital to transition towards a new energy infrastructure. Regardless of whether the impact of regulations is positive or negative, energy utilities are left in a position where they are expected to provide greater returns to investors and invest capital in a smart, decarbonised energy grid while facing increased competition at a national and international level.

1.2.2 The Impact of Environmental Policy

Beyond liberalisation objectives, another major EU-led reform thrust that has built up particular momentum over recent decades is related to environmental concerns and the desire for a ‘green’ energy supply. Energy utilities have been subjected to regulations aimed at decarbonising the energy sector and increasing their use of renewable energy-generating technologies, thereby exposing utilities to additional financing costs, technological risk from the use of relatively new generating technologies and also revenue volatility due to competition from renewable energy sources.

Environmental policy and green-competition[6] are expected to have a negative effect on the accounting returns of gas- and coal-fired power plants. Since electricity cannot be efficiently stored, grid operators are responsible for balancing supply and demand at all times (Jamasb and Pollitt, 2005). Any electricity network must provide both power, an instantaneous rate of output, and energy, a cumulative output over time; power and energy are often defined as peak and base load, respectively (Söderholm, 2001). Traditionally, large power plants, such as coal or nuclear, supplied the base load power required on energy grids, while gas-fired plants operated during peak times to meet demand.

In recent years, renewable energies such as solar and wind have been given ‘grid priority’. Grid priority ensures that renewables can utilise their generating capacity and sell energy to the transmission networks ahead of fossil-fuel generators. This has led to an inability for the traditional power plants to sell their electricity to transmitters, forcing fossil fuel generators to compete for residual grid capacity. These intermittent energy sources can only operate in favourable weather conditions and tend to generate the greatest amount of energy during the daytime, coinciding with the peak hours, which were historically the most profitable hours for combustion fuel generators (Newbery, 2015). Further, volatile weather conditions transfer through to wholesale spot prices (Green and Vasilakos, 2010).

As many renewable technologies have very low short-run marginal costs, full participation in the wholesale market, even without grid priority, is likely to result in their full dispatch in normal conditions (Riesz and Milligan, 2015). As a result of the aforementioned, the large generating capacities of combustion fuel generators become stranded. Traditional

---

[6] Green-competition refers to competition between fossil-fuel and renewable energy utility companies. It is a form of competition based solely on the supply grid’s preference for ‘green’ energy, often supported by subsidiaries and disadvantaging fossil-fuel utility companies.

fossil-fuel generators are cumbersome in comparison with modern, clean energy solutions. Large generators have *minimum loads* of approximately 50-70% of the unit's capacity, the lowest level a plant can operate at without completely shutting down, finding it difficult and costly to scale back operations (Green and Vasilakos, 2010, Riesz and Milligan, 2015).

However, large generators are still crucial to preventing power outages and must remain available to generate electricity in during brief periods of scarcity. Some generators are incentivised to place negative bids into the wholesale market during low residual loads as turning off would incur additional costs and risks (DECC, 2010). This phenomena of negative pricing indicates the system requires flexibility improvements (Hogan, 2005). As prices are disconnected from opportunity costs, lower wholesale prices leave incumbents unable to recoup the necessary return on thermal investments and new entrants cannot establish market capitalisation at the necessary level to finance new base-load assets without additional payments beyond the energy market (Caldecott and McDaniels, 2014, Newbery, 2015, Robinson, 2015).

Where market valuation is based on investor's perception, it is also important to consider the social benefits of increased renewable objectives. More than ever, investors are monitoring the actions of managers regarding the social responsibility of a company (Ansar et al., 2013). The concept of socially responsible investing has also gained prominence in recent years, with environmental performance identified as a criterion assessing whether a firm is a good investment (Filbeck and Gorman, 2004). The first impact regarding the cost of social responsibility relates to the perception that control over pollution and maximising profits are assumed to be mutually exclusive. Managers perceive that the two cannot co-exist and the former can only be achieved at the expense of the latter (Bragdon and Marlin, 1972, Walley and Whitehead, 1994).

There is some empirical evidence that environmental compliance can lead to an increased financial burden for a firm (Gollop and Roberts, 1983, Hart and Ahuja, 1996, Koch and Bassen, 2013). A prominent market instrument developed in recent years is the EU ETS, designed to provide short- and long-term CO_2 emission price signals through the trade of carbon allowances. The high cost of emissions should, in theory, motivate innovation and investment in lower-carbon energy sources. However, Robinson (2015) highlights that the mechanisms has been ineffective to date for three reasons: 1) a variety of parallel mechanisms and mandatory renewable energy source (RES) targets which undermined the EU ETS market; 2) an over-allocation of permits which resulted in oversupply; and 3) the EU ETS was not designed to deal with an economic recession, where overall energy demand and production declined, reducing the demand for emission allowances.

The reputation of the firm is also of concern, where Klassen and McLaughlin (1996) and Filbeck and Gorman (2004) examine the linkages between financial return and the environmental management of firms. While positive (negative) environmental performance has a positive (negative) impact on firm value, the impact of positive responses is often lower for firms in environmentally unfriendly industries, possibly indicating market scepticism about environmental efforts (Klassen and McLaughlin, 1996).

1.3 Research Objectives

In line with the research questions and motivation outlined respectively in Sections 1.1 and 1.2, this thesis addresses four overarching objectives, namely: 1) developing an approach to estimating risk premia in European energy utilities; 2) refining the approach to examine within-sector heterogeneity, testing for time-varying risk premia and isolating the firm-specific component of returns; 3) identifying the timing at which information regarding regulatory changes is incorporated into asset prices; and 4) examining the heterogeneous impact of four distinct restructuring streams. Specifically, the following sections discuss the main objectives of this thesis.

1.3.1 A Novel Asset Pricing Model for the European Energy Sector

The majority of asset pricing models today extend the Capital Asset Pricing Model (CAPM) specification, which finds that broad market returns are the major determinant of equity returns. The energy economics literature augments the CAPM to include a variety of risk factors, such as term premium, oil, coal, natural gas and carbon prices. Most research which examines the relationship between markets and commodities can typically be separated into three themes: the impact of commodities on (i) broad market returns (Chen et al., 1986, Jones and Kaul, 1996, Park and Ratti, 2008, Cunado and Perez de Gracia, 2014, Narayan and Gupta, 2015), (ii) multiple sectors and industries (Huang et al., 1996, Faff and Brailsford, 1999, Nandha and Faff, 2008, Arouri, 2011), or (iii) the oil & gas sector (Manning, 1991, Sadorsky, 2001, El-Sharif et al., 2005, Ramos and Veiga, 2011, Elyasiani et al., 2011). Few papers consider energy utilities as a separate sector when estimating commodity risk exposure, with the only relevant papers which examine European energy utilities in isolation being limited to Oberndorfer (2009a) and Koch and Bassen (2013). El-Sharif et al. (2005) and Oberndorfer (2009a), argue that the energy economics literature is restricted due to its reliance on antiquated asset pricing models and the incorporation of standard finance risk factors is an avenue for further research.

Concurrent with the energy economics literature, the finance literature also extends the CAPM to develop asset pricing models which can explain a greater proportion of shared stock market variation. Additional stock market factors, such as size premium (Banz, 1981, Chan et al., 1985, Chan and Chen, 1991) and value premium (Rosenberg et al., 1985, Chan et al., 1991) are incorporated into the CAPM specification. These factors are later consolidated into the three-factor asset pricing model by Fama and French (1992, 1993). Jegadeesh and Titman (1993) find momentum premium to be a significant risk factor of equity returns, which Carhart (1997) integrates into the three-factor model to produce the four-factor model. The finance asset pricing models are typically implemented at the global, market level and perform poorly when explaining average returns at the local, sector level (Fama and French, 1997).

The first objective of this thesis, addressed in Chapters 4 and 5, is to integrate the two bodies of literature to **introduce a new asset pricing model to explain returns in the European energy utility sector – the AFFM.**[7] Chapter 4 utilises a global, market-level AFFM to examine how the returns of the energy sector behave relative to other European sectors. The objective is to test whether the AFFM is superior to other asset pricing model specifications. In Chapter 5, the model is adapted for sector-level analysis, the local AFFM, **explaining average sector returns and within-sector return heterogeneity**.

1.3.2 Examining Time-Varying Risk Premiums

Based on the assumption of stationarity in time series, it is often assumed that the parameters of the model, such as mean, variance and trend, must remain constant over time despite little economic rationale to support this (Chow, 1960, Andrews, 1993). Previous literature has shown that the estimated relationship between industry returns and risk factors is not stable across time, with temporal sensitivity which affects significance (Huang et al., 1996, Fama and French, 1997, Faff and Brailsford, 1999, El-Sharif et al., 2005, Boyer and Filion, 2007). The inter-temporal variability in the previous literature was identified by separating the time series into annual (or six month) regressions, or separating the series into distinct periods, for example, pre- and post-war. Neither are optimum choices unless the break dates are known with certainty. The inclusion of surplus observations, which are not affected by structural breaks, will skew the mean residuals towards the expected value of zero,

---

[7] Note, the name of the three- and four-factor models pertains to the fact that there are three or four stock market risk factors which explain equity returns, while the augmented-CAPM modifies the CAPM to include term premium and various commodity risk factors (oil, coal, natural gas and carbon). Accordingly, the ‘Augmented-four-factor Model’ title is chosen as the pricing model includes four stock market factors (market, size, value, momentum) and augments the model with term premium and commodity risk factors (oil, coal, natural gas and carbon) – thus combining the naming convention of the finance and energy economics literatures.

reducing the power of any statistical tests and biasing the results against significance (Quandt, 1960).

The econometrics literature addresses the assumption of parameter stability, initiating much of the structural break literature. Structural breaks can affect the results of the model in a number of ways, such as a change in the relationship with the risk factor, the intercept or variance. Tests can be implemented in the case of a ‘pure’ structural change, where the entire parameter is subject to change, and for the case of ‘partial’ change, where only a component of the parameter vector changes. Bai and Perron (1998, 2003) develop an algorithm based on the principle of dynamic programming, allowing computation of estimates of the break points as global minimisers of the sum of squared residuals. This is achieved through partitioned regressions and cluster analysis, curve fitting by use of segmented straight lines (polygonal curves) and grouping for maximum homogeneity by minimising variance within groups; see, respectively, Guthery (1974), Bellman and Roth (1969) and Fisher (1958).

The second objective of this thesis, addressed in Chapter 5, is **demonstrating the inter-temporal variability of risk premia**. First, this is achieved by **implementing annual conditional regressions** in a similar manner to El-Sharif et al. (2005). Second, the thesis **implements the partial and pure structural break point tests of Bai and Perron (1998; 2003) to accurately identify structural breaks in parameters through time.**

1.3.3 Capturing the Market Reaction in the Ordinary Legislative Procedure

A core assumption of finance literature is that investors are expected to be rational, wealth-optimising individuals. When information is anticipated or becomes public knowledge, information is immediately impounded into stock prices; any sudden change in value implies that the market has changed its assessment of future cash flows or perceived riskiness (Schwert, 1981, Klassen and McLaughlin, 1996).

To achieve this objective, Chapter 2 of this thesis constructs a large list of 54 regulatory events expected to affect returns in the energy sector. The chapter also presents an overview of the European ordinary legislative procedure, addressed in Section 2.1. The outline highlights the key political institutions that are pivotal in the adoption of legislation, the procedure by which they vote and a timeline of the legislative process. The European ordinary legislative procedure is the main legislative process by which directives and regulations are adopted at the European level. The co-decision procedure is central to the European Community's decision-making system, and is designed to increase the transparency, accountability and efficiency of the legislative process. While the legislative procedure is lengthy and complex, it is also well documented. The legislative procedure serves as an ideal instrument to explore market efficiency within Europe, as key stages of the process, including public readings, voting, signing and publication, can be identified as a legislative act passes from proposal to adoption. To date, no papers exist on market efficiency and the timing of market reaction surrounding key stages of the European ordinary legislative procedure. Using the propositions from Chapter 2, combined with theory regarding asset pricing and the impact of regulatory changes, Chapter 6 implements an event study approach on key stages of the legislative procedure.

The third objective of this thesis, addressed in Chapter 6, is to examine the market efficiency and transparency of the EU legislative procedure. This is achieved by implementing an event study approach to **explore the timing of market reaction surrounding key stages of the ordinary legislative procedure.**

1.3.4 Examining the Differential Impact of the Four Restructuring Streams

The liberalisation and decarbonisation objectives of the energy sector can be divided into four distinct streams, including 1) Internal Energy Market, 2) Energy Efficiency, 3) Renewable Energies and 4) Security of Supply. The four streams are discussed in detail in Section 2.2. The objective of liberalisation was to provide incentives for European utilities to improve their capital investment decisions, operating performance and operating efficiency, with the projection that end consumers would benefit from internal efficiency gains (Berger and Humphrey, 1997, Jamasb and Pollitt, 2000). The objectives of liberalisation were varied and numerous, and thus this thesis addresses the restructuring stream as a whole. Liberalisation's objectives were expected to be achieved through 1) privatisation, 2) lowering entry barriers for new utilities, 3) increasing competition and 4) unbundling vertically integrated utilities. Industry privatisation also reduces the number of state-owned enterprises, removes government-backed debt guarantees and exposes firms to the real threat of bankruptcy (Megginson et al., 1994). Lowering entry barriers increases the freedom of entry and exit to any industry, resulting in more start-up companies and increased competition from large, international competitors (Beneish, 1991, Gual, 1999). Deregulated and saturated markets face new pressures such as international brand awareness and marketing of services to gain custom (Delmas and Tokat, 2005), while the unbundling of vertically integrated utilities also reduces insurance against fluctuations in commodity, wholesale and end-user price (Jamasb and Pollitt, 2005).

Various papers examine the historical and predicted impact of increased environmental burdens on the operating and financial return of energy utilities (Gollop and Roberts, 1983, Hart and Ahuja, 1996). Some empirical papers have implemented an event study approach surrounding events regarding environmental management, crises, performance or press releases (Klassen and McLaughlin, 1996, Filbeck and Gorman, 2004, Griffin et al., 2015). The general tenor of the results in the literature is that markets react positively surrounding positive environmental events, such as strong environmental management, but negatively surrounding events which will negatively impact future cash flows.

The fourth objective of the thesis, addressed in Chapter 6, is to **examine the impact of the four restructuring streams on the valuation of European energy utilities using an event study methodology**.

1.4 Research Hypotheses

There is one central research question for the work of this thesis, addressed through three empirical chapters. From the preceding discussion, it is clear that both the academic literature and the press acknowledge the impact of liberalisation and environmental objectives on the valuation and cost of capital of stocks (see Section 1.2). The impact of regulatory changes in the context of EU energy utilities has, for the most part, been addressed by the European press in an anecdotal and superficial manner. The press has formed arguments on the basis of incomplete information, an unrepresentative sample of large natural gas utilities and little rigorous empirical evidence. Accordingly, the overarching hypothesis for this thesis is the following:

Central hypothesis: Liberalisation and decarbonisation objectives have significantly affected the financial return and valuation of the European energy utility sector throughout sector restructuring.

This is a non-directional hypothesis since the impact of regulation will depend on the type of regulations, as distinguished by the four streams, and the type of energy utility it addresses. This central hypothesis is addressed through a series of chapter-specific research questions, analytical foci and hypotheses. The three chapters of this thesis employ a multi-model approach. As noted in Section 1.1, the analyses in Chapters 4 and 5 are prerequisites to examining the impact of regulatory changes on the firm-specific component of returns, as current energy economic models are outdated and standard finance models perform poorly at explaining returns at the sector level. Chapters 4 and 5 do, however, make individual contributions in terms of explaining returns, developing a sector-specific asset pricing model and isolating the firm-specific component of returns. Chapter 6 contains five hypotheses, which address the timing of market reaction and the impact of regulatory changes using the local AFFM developed in Chapter 5. The following paragraphs provide a brief outline the research questions, analytical foci and hypotheses, which are presented in Section 1.1 and addressed in greater detail within the respective chapters (Chapters 4 to 6).

Chapter 4 addresses four research questions. Based on propositions of the energy economics and finance literature, Chapter 4 integrates standard finance risk factors, term premium and commodity risk factors into a single asset pricing model – the global AFFM. The former two research questions relate to the impact of stock market and commodity risk factors on the energy utility sector. The latter two research questions relate to the inter-sectoral and inter-temporal nature of risk premia. Chapter 4's results show that the global AFFM is a superior asset pricing model in comparison with existing asset pricing specifications. The results of Chapter 4 motivate the analysis of Chapter 5.

Chapter 5 focuses on refining the global AFFM for sector level applications. Chapter 5 addresses four analytical foci. Based on propositions of Moskowitz and Grinblatt (1999) and Fama and French (1997, 2012), the unique characteristics of the energy sector are expected to be major determinants in explaining sector returns. The first analytical focus concerns whether local stock market risk factors increase explanatory power compared with global stock market risk factors. The purpose of the improved model, with tighter regression fits, is to increase the precision of estimated coefficients. The second analytical focus examines within-sector heterogeneity, exploring whether risk factors differ for firms grouped on similarity of characteristics. The third analytical focus introduces recent advances in econometric literature, comparing whether the inductive Bai and Perron (1998, 2003) structural break point test is better able to capture the structural breaks in the relationship between sector returns and risk premia compared with deductive annual regressions. Finally, the fourth analytical focus explores the ability to capture the firm-specific component of returns. The ability to better isolate the firm-specific component of returns has implications for the model selection and measurement of abnormal returns in Chapter 6.

Chapter 6 utilises the local AFFM of Chapter 5 to address two overarching research questions relating to: 1) the timing of market reaction surrounding key stages of the legislative procedure and 2) the market's unique response to the four distinct restructuring streams (Internal Energy Market, Energy Efficiency, Renewable Energies and Security of Supply). The two overarching research questions are addressed through five chapter-specific hypotheses.

In an efficient market, information is impounded into stock prices when it is first anticipated or becomes public knowledge; any sudden change in value implies that the market has changed its assessment of future cash flows or perceived riskiness (Schwert, 1981, Klassen and McLaughlin, 1996). The protracted and complex nature of the ordinary legislative procedure enables an investor to closely monitor the likely outcome of a legislative proposal. Chapter 6 examines four key stages of the regulatory procedure and predicts that investors will react at the early stages, when only the political institution's votes are known, rather than the latter stages of the process, when the document is signed and published and no new informational content is available. The first hypothesis predicts:

$\boldsymbol{H_1}$: *Significant market reactions to regulatory changes will predominantly occur in the early co-decision stages of the legislative procedure.*

The second set of hypotheses predict that the four distinct restructuring streams will have a negative impact on energy sector returns and valuation. However, the impact will be unique depending on the stream and the energy utility analysed. To explore this impact to its fullest extent, the tests are implemented on 12 energy portfolios outlined in Section 1.5.4 to examine within-sector heterogeneity of the market reaction to the regulatory changes. These latter hypotheses represent the main contribution of this thesis. The four hypotheses concerning the impact of regulatory changes are as follows:

$\boldsymbol{H_2}$: *Liberalisation objectives related to the Internal Energy Market stream will negatively impact the financial return and market value of energy utilities, in particular large incumbent utilities that have historically had market power.*

$\boldsymbol{H_3}$: *Environmental objectives related to the Energy Efficiency stream will negatively impact the financial return and market value of energy utilities across the entire sector since it reduces overall energy consumption.*

$\boldsymbol{H_4}$: *Environmental objectives related to the Renewable Energies stream will negatively impact the financial return and market value of energy utilities, in particular natural gas and hydrocarbon-intensive utilities.*

$\boldsymbol{H_5}$: *Measures to safeguard European energy supply, related to the Security of Supply stream, will negatively impact the financial return and market value of energy utilities.*

The following section outlines the thesis' originality and contributions.

1.5 Research Originality and Contributions

1.5.1 A Novel Asset Pricing Model for the European Energy Utility Sector

El-Sharif et al. (2005) and Oberndorfer (2009a) observe that that the existing energy economics literature is limited, as existing asset pricing models fail to incorporate established finance risk factors. Thus, the asset pricing model developed in this thesis reintegrates the energy economics and finance literatures to develop a model which is superior at capturing return variability in European energy utilities - the AFFM. The stock market risk factors include size, value and momentum premia.

Two versions of the AFFM are created. Chapter 4 utilises the global (market level) AFFM, calculating the stock market risk factors across a diverse sample of European stocks. This specification is comparable to Fama and French's (2012) 'global' asset pricing model, where the stock market risk factors can be used to explain the returns across multiple sectors. The stock market risk factor coefficients explain energy sector returns *relative to European stocks*. For example, do returns in the energy sector behave like 1) European winners (upper momentum) or losers (down momentum), 2) like big or small European stocks 3) or like European value or growth firms? This interpretation is useful, as it also explores whether energy utilities have a unique exposure to risk premia compared with other sectors. Chapter 4 also addresses whether the inclusion of stock market risk factors increases the model's goodness of fit. The results show that the stock market factors are larger determinants of sector returns than commodity risk factors.

Fama and French (2012) show that these 'global' specifications typically perform poorly at the 'local' level when explaining average returns. Chapter 5 implements a second version of the AFFM based on Fama and French's (2012) 'local' asset pricing model. The chapter independently recalculates the stock market risk factors at the sector level – using only 88 European energy utilities. This second specification is implemented in two ways. First, the sector level AFFM can be used to explain average returns of the energy sector. For example, can the average returns of the energy sector, as a whole, be explained by the returns of the biggest or smallest energy utilities? The second application is to examine the *within-sector* return heterogeneity, for example, 1) does risk exposure of small and big energy utilities differ, or 2) does risk exposure of electricity and natural gas utilities differ? The sector level AFFM shows much tighter regression fits and explains a greater proportion of returns within the energy sector.

1.5.2 Examines Time-Varying Risk Factors

The thesis contributes to the literature by empirically determining the point at which the risk premia undergo pure or partial structural breaks, controlling for the non-linearity of coefficients and the evolution of risk premia through time. While the deductive method of breaking the series into distinct periods or implementing annual regressions has been utilised in the literature, econometric issues regarding this approach exist (see Section 1.3.2). This thesis makes a novel contribution to the literature by incorporating recent advances in the econometrics literature, implementing an inductive Bai and Perron (1998; 2003) structural break point test. The inductive break point tests are an improvement over the deductive approach, as it overcomes many methodological issues which can bias estimated coefficients and significance tests (discussed in Section 3.3.4). Further, it makes no assumptions regarding the break dates, and utilises a dynamic algorithm to identify unknown break points. The empirical results show that the Bai and Perron (1998; 2003) does a better job than deductive methods at identifying structural breaks through time, and can dramatically improve the explanatory power of the asset pricing models. Further, results show inter-temporal variability in the risk premia through time, which demonstrates the evolving relationship between risk factors and returns.

1.5.3 Improved Isolation of Firm-Specific Component of Returns

As shown in Chapter 5, the assumption of constant risk factors forces any changes in the relationship between risk factors and returns into the residuals of an unconditional linear regression. The firm-specific component of returns can be more accurately captured through the use of the local AFFM and employing annual conditional regressions or inductive break point tests. The break point test utilises partitioned regressions and cluster analysis, curve fitting by use of segmented straight lines, and grouping for maximum homogeneity by minimising variance within groups (see, respectively, Guthery, 1974; Bellman and Roth, 1969; Fisher, 1958). This approach is extracted from the econometrics literature and is novel to the energy economics literature. The two-pass method implemented in Chapter 5 is also novel. The results show that the assumption of constant parameters results in an inability to precisely isolate the firm-specific component of returns, where residuals continue to capture the impact of risk premia. Thesis results show that, for this thesis' sample and time period, this changing relationship with risk premia accounts for 28% of the residuals' variability. The inductive break point is superior at isolating the unsystematic component of returns. The results also show that conditional regressions, similar to that implemented by El-Sharif et al. (2005), can proxy for an unsophisticated alternative approach to isolating the firm-specific component of returns and filtering out the impact of risk premia; however, this approach remains suboptimal, as it does not address the econometric criticisms.

1.5.4 A Superior European Energy Utility Sample

Through extensive research, this thesis dramatically increases the sample size of European energy utilities used in the empirical analysis relative to the existing literature. This thesis includes 88 European utilities, across all operations of the electricity and natural gas industries. In comparison, the closest sample to this thesis includes Koch and Bassen (2013) and Oberndorfer (2009a), where Koch and Bassen (2013) examine carbon risk exposure of 20 publicly traded European electric utilities (excluding natural gas utilities), while Oberndorfer (2009a) examines 11 oil & gas firms and 11 electric utilities extracted from the STOXX® utilities index. Further, Oberndorfer (2009a) removes utilities whose operations are based on renewable energy, creating an unrepresentative sample of European energy utilities. Many of the companies included in the two samples represent the largest energy producers in Europe, and neither sample controls for survivorship bias, thus making any historical analysis of regulatory changes unrepresentative as, by definition, all companies in the sample have survived the changes in the regulatory and operating environment.

Finally, the sample used in this thesis uses a portfolio approach to delineate energy utilities into groups based on firm characteristics. To date, the differential impact of risk premia for European energy utilities has only been studied using Koch and Bassen's (2013) delineation based on carbon-emissions and Oberndorfer's (2009a) delineation between the energy sector and the oil & gas sector. This thesis delineates the sector into 1) small and big utilities; 2) growth, neutral or value utilities; 3) upper, medium or down momentum utilities; and 4) electric, natural gas or multi-utilities. This is the first time European utilities have been delineated into such portfolios and will provide much needed insight into the heterogeneous peculiarities and return profiles of various European energy utilities. In particular, the return profile and impact of regulations on small utilities has not been analysed. This is important from a policy perspective, as the various legislation was expected to negatively impact big utilities and provide growth opportunities for smaller utilities (as discussed in Section 2.2.1).

1.5.5 Market Reaction within the Ordinary Legislative Procedure

To date, no academic paper has examined the timing of market reaction to key stages of the European ordinary legislative procedure, especially from a finance perspective. To this end, this thesis provides a detailed understanding of market efficiency and transparency in the EU legislative procedure. It demonstrates that investors are reacting to information at early stages of the legislative procedure, sometimes before official voting positions have been announced. This is expected due to the protracted and public nature of the procedure. Key stages of the procedure which occur later, such as the press release and the signing of the legislative texts, are relatively superfluous, with little to no market reaction surrounding these stages. This implies that the informational content has already been impounded into prices.

1.5.6 Examination of the Impact of Different Regulatory Steams

Finally, this thesis is the first to examine the impact of the four restructuring streams on the valuation of European energy utilities (see Section 1.1). While press conjectures on the impact of these streams, no prior research has examined the market reaction surrounding regulatory changes or distinguishes between Internal Energy Market, Energy Efficiency, Renewable Energies and Security of Supply agendas. The market reaction surrounding the four streams has implications for the market's assessment of future cash flows (Schwert, 1981, Klassen and McLaughlin, 1996), required rates of return on investment and the likelihood of achieving ambitious decarbonisation goals at the European level.

1.6 Organisation of the Thesis

The structure of the thesis chapters, and the organisation of the chapters, is outlined in Figure 1.3. The thesis consists of seven chapters in total, three of which are empirical studies.

1.6.1 Chapter 1: Introduction

This chapter represents the thesis introduction, introducing the thesis' research objective by providing an overview. Further, this chapter outlines the motivation for examining the impact of regulatory changes, hypotheses, objectives and contribution of the thesis.

1.6.2 Chapter 2: European Energy Sector Reform

To place the thesis in context, Chapter 2 introduces the ordinary legislative procedure, the main legislative procedure through which the majority of European legislative proposals are proposed and adopted. The chapter provides a detailed outline of the legislative procedure, the political institutions involved in creating European legislation and the voting process of the political institutions. The chapter also outlines the list of restructuring legislation analysed later in the thesis. Throughout the chapter, key stages where information can diffuse into the market are highlighted, which helps develop H_1 for Chapter 6 regarding the impact of regulatory changes and the timing of market reactions, which has implications for market efficiency. The chapter continues by providing an overview of the four distinct restructuring streams of the European energy utility sector the: Internal Energy Market, Energy Efficiency, Renewable Energies and Security of Supply streams. Particular emphasis is placed on the differences between the four streams, outlining the intended objectives of each stream and types of utilities that each stream targets. The discussion, combined with the literature review in Chapter 3, help develop ***H*$_2$** to ***H*$_5$** for Chapter 6, regarding the unique impacts of the four restructuring streams.

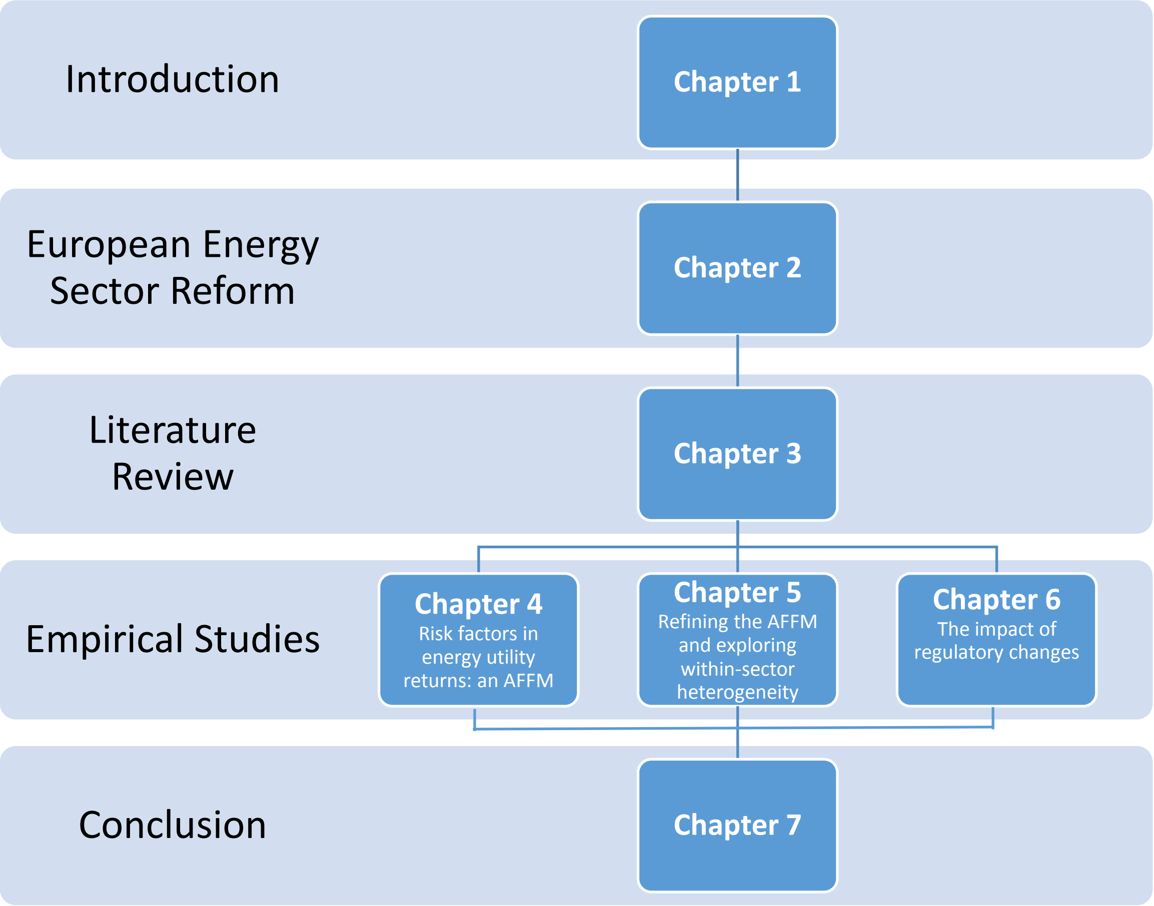


FIGURE 1.3: ORGANISATION OF THE THESIS CHAPTERS

This figure presents the organisation of the thesis' chapters. Chapter 1 presents the thesis introduction. Chapter 2 outlines the ordinary legislative procedure and the four distinct restructuring streams. Chapter 3 contains the overarching thesis literature review. Chapters 4 to 6 are the three empirical studies. Chapter 7 concludes the thesis.

1.6.3 Chapter 3: Literature Review

Chapter 3 provides a synthesis of the multiple bodies of literature the thesis draws upon. The literature review begins by outlining shared asset pricing models. The asset pricing models are taken from finance and energy economics literature, both of which extend the CAPM. The literature review demonstrates that the two strains of this literature begin to diverge from one another in the early-1990s. The finance literature develops the four-factor model of Fama and French (1993) and Carhart (1997) which identifies stock market risk factor as additional risk factors in explaining equity returns. The energy economics literature develops the augmented-CAPM which identifies macroeconomic variables such as term premium and commodities, as additional risk factors in equity returns. The chapter independently reviews the current state of the finance and energy economics literatures, then recombines the two bodies of literature to develop the AFFM, providing the theoretical groundings for Chapter 4.

Following the asset pricing model literature, the literature review continues by presenting research concerning measuring the impact of regulatory changes on stock performance, in particular, the potential impact of liberalisation and environmental objectives on the valuations of equities. After outlining the expected impact of regulations, the literature review focuses on propositions from the econometrics and statistics literature regarding the time-varying nature of risk premia. The section outlines theory and empirical evidence regarding the estimation of pure and partial break points in the relationship between stock returns and risk factors over long horizons. The literature review ends with a section concerning expected methodological limitations to asset pricing. Specifically, the section outlines literature concerning the portfolio approach and the impact of commodity hedging on significance tests.

1.6.4 Chapters 4 to 6: The Three Empirical Studies

The broad policy and academic objectives of this thesis are addressed through three empirical studies, spread across three chapters of the thesis. The three studies include

- **Chapter 4:** Risk factors in energy utility returns: An Augmented-Four-Factor Model (AFFM),
- **Chapter 5:** Refining the AFFM and exploring within-sector heterogeneity, and
- **Chapter 6:** The impact of regulatory changes in energy utility returns:

Chapters 4 to 6 form the core empirical analyses of this thesis. The chapters are summarised in Figure 1.3. Each chapter can be read as a standalone study, but are linked sequentially. Each of the three studies includes an introduction, methodology, results and conclusion section. As the literature review is shared across all three studies, the studies utilise cross-referencing to avoid a verbose thesis. Where appropriate, an additional chapter-specific literature review or hypothesis development section is provided.

Chapter 4 of the thesis focuses on integrating the energy economics and finance literatures, using propositions from both bodies of literature to develop a global[8] augmented

---

[8] Note, this thesis adopts the terms 'global' and 'local' to define variable scope from a statistics perspective. Global risk factors are stock market risk factors calculated using a diverse sample of European stocks. Global risk factors are expected to be applicable across multiple functions; global risk factors can be used to explain

version of the traditional four-factor model of Fama and French (1993) and Carhart (1997). This thesis defines this novel model as the Augmented-Four-Factor Model, henceforth referred to as the AFFM throughout the remainder of this thesis. The chapter explains the behaviour of the energy sector's returns relative to other European sectors, identifying whether significant risk factors represent a sector-specific relationship or market-wide conditions.

Chapter 5 of the thesis, has multiple objectives. First, the chapter implements a local version of the AFFM to explain average returns of the energy sector as a whole; for example, do sector returns behave like big or small energy utilities? Second, the chapter continues by examining within sector heterogeneity in various portfolios of energy utilities grouped on similarity of characteristics, including two size portfolios, three book-to-market portfolios, three momentum portfolios and three industry portfolios. Third, Chapter 5 identifies time-varying risk premia using deductive and inductive empirical approaches and is able to more accurately isolate the firm-specific component of returns for the European energy utility sector. To date, no article has developed such a model for European energy utilities.

Chapter 6 of the thesis, contributes to the literature by implementing an event study analysis on a broad range of regulatory changes in the European energy utility sector. The chapter identifies the timing of market reaction surrounding key stages of the European legislative procedure, and also measures the impact of four major restructuring streams.

Each study adopts interdisciplinary approaches across finance, energy economics, econometrics, accounting, and energy and environmental policy research. For instance, Chapter 4 is primarily based in the field of finance and energy economics, testing a variety of asset pricing models which are able to explain returns across various sectors. The chapter uses common extensions of the CAPM, and proposes the global AFFM as a novel model for this thesis. Prior literature has argued that 'global' existing asset pricing models typically result in poor performance at the 'local' level, and has found temporal variability in risk premia (Huang et al., 1996, Fama and French, 1997, Faff and Brailsford, 1999, Sadorsky, 2001, El-Sharif et al., 2005, Boyer and Filion, 2007, Oberndorfer, 2009a). Chapter 5 incorporates propositions from the finance literature to address the poor performance of asset pricing models at the sector level, and propositions from the econometrics literature to address the

---

returns across a variety of sectors. In contrast, local risk factors have limited scope and are sector-specific. Local stock market risk factors are calculated using only the 88 European energy utilities identified in this thesis, therefore, are expected to better explain sector level returns. Fama and French (2012) use similar distinctions when calculating global versus local risk factors, explaining average returns across integrated markets and regional markets, respectively. The terms 'global' and 'local' should not be confused with location in a geographical sense.

time-varying nature of risk premia. Chapter 5 also incorporates the Bai and Perron (1998, 2003) structural break point test from the econometrics literature. Chapter 6 studies the legal-linguistic content of the legislation to examine the impact of legislative proposals on the valuation of energy utilities, incorporating propositions from the finance, energy economics, accounting, and energy and environmental policy literature. The hypotheses for the chapters are developed from a combination of existing empirical research, propositions from literature and *ex ante* expectations of impact outlined in the legislative acts.

The three studies produce a variety of results which are of interest to both academics and policy-makers. The former two studies will be of interest to academics, while the third chapter will be of interest to policy-makers. Regarding the asset pricing model results, the findings of this thesis reveal that the augmented-CAPM implemented in the energy economics literature can benefit from the inclusion of additional stock market risk factors – extracted from the finance literature. These risk factors include size premium, value premium and momentum premium. The global AFFM in this thesis consistently has greater explanatory power across all tests. This explanatory power can be increased further by substituting global (market- level) risk factors for local (sector level) risk factors, as sector-level risk factors typically have tighter regression fits (Moskowitz and Grinblatt, 1999, Fama and French, 2012). Further, controlling for the time-varying nature of the model parameters has a greater impact on explanatory power than the inclusion of additional variables. As expected, the novel model is also superior at isolating the firm-specific component of returns. Regarding the policy results, the thesis shows that markets are extremely efficient and incorporate information into asset prices during the early stages of the legislative procedure – prior to the proposal’s signing. Results show that the Renewable Energies regulations have had a relatively limited impact on sector returns. Notably, the Energy Efficiency and Internal Energy Markets streams have had a significant impact on sector returns.

1.6.5 Chapter 7: Conclusions

Chapter 7 provides a broad conclusion for the thesis on the basis of the results drawn from Chapters 4 to 6 and the literature review (Chapter 3). The policy implications are compared with the overall policy objectives of liberalisation and decarbonisation of the energy sector. The chapter concludes by outlining the limitations of the thesis and suggesting avenues for further research.

CHAPTER 2

EUROPEAN ENERGY SECTOR REFORM

The major contribution of this thesis is to develop an asset pricing model which is able to capture variability in the returns of European energy utilities, and to use that model to more accurately examine the impact of regulatory changes on the valuation of European energy utilities. This is achieved by utilising an event study approach in Chapter 6 to examine how regulatory changes impact the firm-specific component of returns, filtering out any impact from stock market factors, term premium and commodity risk factors. This underlying firm-specific component of returns is expected to vary when markets perceive that the underlying value of the firm has been affected by changes in the operating or regulatory environment. Market efficiency assumes that investors incorporate any information regarding changes to future cash flow, including those as a result of regulatory changes, into stock prices when the information is first anticipated by the market. Investors are expected to consider all possible scenarios, including those which are hard to value (Griffin et al., 2015). To this end, it is important to outline the context in which regulatory changes are proposed and implemented in Europe, and to outline possible points at which information can diffuse into the market. This section demonstrates that the legislative procedure of the EU is complex and protracted and involves a large number of interveners. As a result, there are many points at which investors can gather information regarding the likelihood of a legislative proposal successfully passing through the procedure and then can react accordingly.

This chapter addresses three objectives: 1) to outline the legislative procedure, 2) to develop key stages at which we expect investors to anticipate that a legislative proposal will come to completion and 3) identify four distinct restructuring streams which are expected to have differential impacts on the energy sector. Section 2.1 addresses the former two objectives, while Section 2.2 outlines the four distinct restructuring streams, encompassing liberalisation and decarbonisation objectives.

2.1 The Ordinary Legislative Procedure

The *ordinary legislative procedure* is the main procedure by which the majority of EU laws are proposed and adopted. Within the EU, there are three independent political institutions jointly responsible for the creation of legislative acts: the EU Commission, the European Parliament and the Council of the EU. From here on in, they are respectively referred to as the Commission, the Parliament and the Council. Each institution reflects a unique role in the procedure. The Commission ensures laws are adopted across Member

States, the Parliament represents the interest of EU citizens, while the Council represents national ministers.

Both the Parliament and the Council are responsible for voting on the adoption, amendment or rejection of legislative proposals. The 'co-decision' procedure requires that the political institutions are in agreement. The purpose of identifying multiple events in the policy formation process is to define events which may either significantly alter expectations regarding the effects of outcomes or the likelihood of a given outcome, or both (Schipper and Thompson, 1983). Typically, the first announcement to adopt or amend an act is referred to as the '1st position', while the second announcement to adopt is referred to as the '2nd position'. These two stages of the legislative procedure, often referred to as the co-decision stages, will be examined using the event study method. The co-decision procedure was designed to ensure the legislative process is transparent, accountable and efficient. Further, the procedure was designed to reconcile differences in opinion and, where applicable, encourage the adoption of legislative proposals at an early stage of the procedure (European Parliament et al., 2007). The legislative procedure is briefly summarised in Figure 2.1, while a detailed outline is provided in Sections 2.1.1 to 2.1.5. Both the European Parliament (2015)[9] and the European Commission (2015) provide an outline of the full legislative procedure.

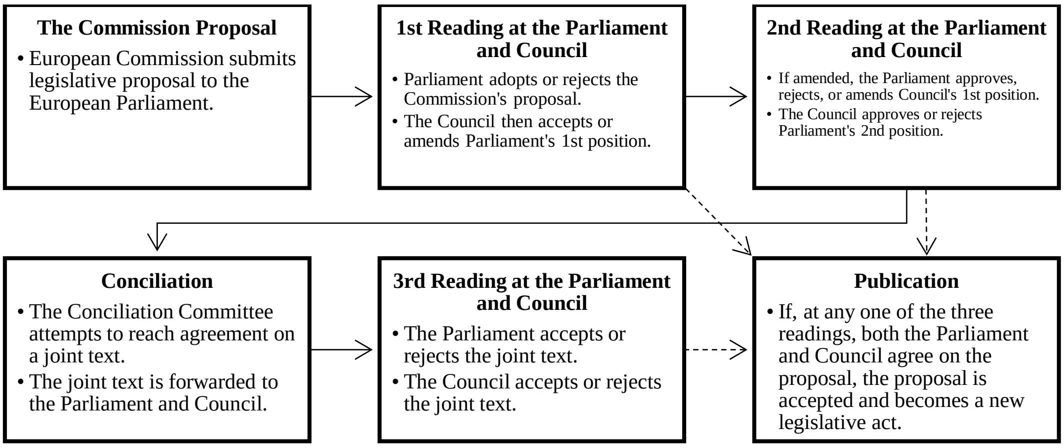


FIGURE 2.1: THE ORDINARY LEGISLATIVE PROCEDURE ADAPTED FROM EUROPEAN PARLIAMENT (2015)

This figure illustrates the European ordinary legislative procedure. Solid lines represent the procedure assuming the two political institutions are not in agreement, which can contain up to three public readings. The dashed lines represent that the two political institutions are in agreement at any of the three public readings, proceeding to the publication stage.

2.1.1 The Commission's Proposal

The Commission is the only political institution with the 'right of initiative', initiating the legislative process by creating a proposal from public or corporate demand. The proposal

---

[9] An interactive, but cursory, version of the ordinary legislative procedure is provided at http://www.europarl.europa.eu/external/html/legislativeprocedure/default_en.htm

is often the result of an extensive consultation process. The Commission is able to alter the legislative proposal, where the legal basis adopted by the Commission determines the legislative procedure, for example, whether the subject of the proposal relates to energy or the internal market.[10] The proposal is simultaneously submitted to the Parliament and the Council for its first reading.[11] As far as possible, any draft texts submitted for discussion at forthcoming meetings are expected to be circulated to all participants well in advance, with the intention of enhancing transparency and informal discussions (European Parliament et al., 2007). The combination of the proposal arising from public or corporate demand, the consultation process and ongoing informal discussions implies that the market can be fully aware of a potential regulatory change and anticipate its forthcoming submission. A prime example of this anticipation of the market can be observed in the Florence School of Regulation. Leading energy-policy academics[12] and the director[13] of the directorate-general (DG) for energy of the European Commission are already in informal, public discussions regarding a potential major regulatory change which is yet to be submitted (FSR Energy, 2015). The major regulatory changes will dramatically change the regulatory and operating environment of energy utilities and will be discussed in Section 2.2.1.

2.1.2 The Parliament and Council's First Reading

Both the Parliament and the Council are the two major political institutions responsible for adopting the legislative proposal. This section outlines first the process of the Parliament, then it outlines the Council's process. The Parliament's process is separated into two stages: 1) deciding a position, and 2) adopting the position. The members of the parliamentary committee responsible for deciding the Parliament's position are named, along with any members of committees which offer opinions on the legislative proposal. Investors are fully aware of the individuals responsible for voting to adopt or reject a legislative proposal, and thus can infer some sentiment towards a legislative proposal. Rational investors

---

[10] The legal basis of the 83 areas of the legislative procedure can be found at http://ec.europa.eu/codecision/docs/legal_bases_en.pdf.

[11] Note, the legislative proposal is also submitted to national parliaments and, where applicable, the Committee of the Regions and the Economic and Social Committee. The aforementioned institutions are not responsible for adopting a legislative proposal; however, they act as a 'watchdog' and can contest a proposal in the early stages of the decision-making process if it is not compliant with the principle of subsidiarity. If opposed, the Commission can decide to maintain the draft so long as they justify their actions, which then continues the legislative process as normal.

[12] Prof. Jean-Michel Glachant, Robert Schuman Chair, Director of the Florence School of Regulation and Director of Loyola de Palacio Energy Policy Programme.

[13] Klaus Dieter Borchardt, Director of the Internal Energy Market at DG Energy of the European Commission on market design and network codes

are expected to consider the interests of the voting individuals in relation to the likelihood that the Parliament would vote to adopt a proposal.

First, a rapporteur prepares a report which outlines the Parliament’s position in advance of the vote. The position is formed on the basis of screening, private consultation and public debate. The parliamentary committee meets on numerous occasions to study the draft report which outlines the Parliament’s position and are able to amend, if necessary, the Commission’s legislative proposal. Amendments are put to a vote, decided by a simple majority, and the committee finalises the draft report outlining the Parliament’s position. Therefore, the Parliament’s discussions convey information regarding the likelihood that the Parliament will vote to adopt or reject a proposal. For the second stage, the position report is placed on the agenda of a plenary session. Additional amendments can be made at this stage, but, as a general rule, amendments must be tabled by noon of the preceding Thursday (European Commission, 2015). The Parliament’s position is relatively fluid until this cut-off point; after which it is unlikely to change.

A plenary debate, which includes the Commissioner, is held ahead of the vote. The plenary vote, based on a simple majority, decides whether to adopt amendments. As no time limit is specified, the Parliament’s phase typically takes 13 to 15 months (European Commission, 2015). The Commission may then alter the legislative proposal to incorporate the Parliament’s amendments. The process above is relatively transparent and prolonged, allowing an investor plenty of time to monitor the production of the reports and gauge the Parliament’s general opinion towards the legislative proposal.

The likelihood of the market reacting to the announcement of the 1st position, and the expectation regarding the proposal’s ultimate adoption, depends on a number of factors. If the legislation arises from strong corporate and/or public demand, a vote to adopt sends a strong signal to the market that political institutions show positive sentiment towards the legislative proposal and aim to seek an agreement. As shown below, the Parliament and the Council are encouraged to reach agreement at an earlier rather than later stage, and therefore a series of informal discussions often occur in advance of the vote. Prior to expanding on this, this section continues by outlining the Council’s voting process.

Concurrent with the Parliament’s vote, the Council also prepares its position. The Council prepares working parties which represent various Member States and are chaired by representatives of the Member State that currently holds the six-month presidency. Equally, the Council’s voting party is well known to investors, as are the interests of the voting individuals. Discussions regarding the Commission’s proposal are held in the public domain. The Council only makes its position known after the Parliament, where the institutions are encouraged to exchange timetables and information regarding progress (European Parliament et al., 2007, European Commission, 2015). Consequently, investors can reasonably expect the Council's position to be announced soon after the Parliament's. Assuming the Council and the Parliament are in agreement, the Council can announce agreement without debate ('A' item) or agreement with debate ('B' item).

Briefly, if the two political institutions are in agreement at the first stage, the legislative act is submitted for the signatures of the Presidents and Secretaries-General of both the Parliament and the Council (see Figure 2.1). The actual completion of the procedure is discussed shortly in Section 2.1.5; the process contains many stages which are of importance for finalising the text. Institutions are encouraged to reconcile their positions so that, where possible, acts may be adopted in the first reading (European Parliament et al., 2007). Between 2004 and 2009, 72% of legislative proposals were agreed upon in the first reading, while 23% were agreed upon in the second reading (European Commission, 2009, European Parliament et al., 2007). Therefore, investors can infer that there is a high probability that a legislative proposal which reaches the first reading will be adopted. If the proposal is amended, then the proposal is likely to be adopted at the second reading. The following sections outline additional phases of the legislative procedure, assuming the two parties are not in agreement.

2.1.3 The Parliament and Council's Second Reading

In some cases, the Parliament and the Council are in disagreement regarding a legislative proposal. Despite disagreement, this stance is denoted a 'common position'. The Council establishes informal tripartite meetings, known as 'trilogues', between the Parliament, the Council and the Commission (European Parliament et al., 2007). As the second reading at the Parliament and the Council is limited to three months per institution, the purpose of the trilogue is to facilitate an early agreement at the second reading of the proposal. Investors are, therefore, aware that the Parliament's position after the second reading must be announced within 90 days. The procedure for the Parliament and the Council is similar to that outlined in the first reading; however, both the Parliament and the Council must also address amendments outlined by the other institution. For brevity, the positions in the second reading can be summarised as 'agreement', 'rejection' or 'amendments'. A vote for agreement (rejection) results in the legislative proposal being adopted (rejected) at the second reading. Should the Parliament amend the document further, the Council enters a second reading and also has a further 90 days to announce a position. The Council may only accept or reject the amendments in the second reading. Acceptance adopts the legislative proposal, while rejection leads to the convening of a Conciliation Committee with the objective of creating a joint document.

2.1.4 The Conciliation Committee and Third Reading

The Conciliation Committee is comprised of equal teams of negotiators from each of the two political institutions, where each team has a mandate for the negotiations, and includes representatives from the Commission. The Commission ensures that the joint text remains congruent with the original proposal. The Conciliation Committee must convene within six to eight weeks to begin the process, which may last up to six weeks in total. Once again, informal trilogues serve a mediating role, with the aim of resolving outstanding issues and creating an amicable 'joint text' in advance of the meeting. The joint text should be balanced and should satisfy both political institutions.[14] The dates, agendas and locations of the Conciliation Committee's meetings are set in advance, informing investors which topics will be discussed and when. As the six-week time limit is often deemed too short, informal negotiations often occur in advance of the Council's second reading (European Commission, 2015). These informal negotiations must signal that the Council are considering amending or rejecting the legislative proposal, and are unlikely to accept the proposal in its current form. Following the meeting of the Conciliation Committee, a press conference is held alerting the media to the outcome of the negotiations (European Commission, 2015). The Parliament and the Council may no longer table amendments to the proposal. The joint document is read publicly a third time, at which point both institutions must vote to adopt the act within eight weeks of receiving the joint text, followed by signatures from both political institutions, otherwise the act is rejected.

The majority of European legislation follows this procedure.[15] Table 2.1 shows a list of energy-specific legislation, analysed later in this thesis, which has passed the ordinary legislative procedure; Section 6.3.3.1 of Chapter 6 outlines the chain-sampling method used to

---

[14] As of January 2015, there have only been four cases where the committee failed to reach agreement on a joint text, demonstrating the Conciliation Committee's effectiveness at solving disputes and the likelihood of a piece of legislation being adopted at this stage (European Parliament, 2015). The cases include 'Voice Telephony' (1994), 'Securities Committee' (1998), 'Working Time Directive' (2009) and 'Novel Foods Regulation' (2011).

[15] A case in point for the European energy utility sector, Directive 1996/92/EC concerning the common rules for the internal market in electricity was originally proposed in 1991. After consultations and presentations, the proposal was amended by the Parliament and the Council in 1993 and 1994, respectively. The Parliament agreed with the second revision on the 11th of December 1996, while the Council agreed on the 19th of December 1996. The proposal was also signed by both institutions on the 19th December 1996. All communication documents were published simultaneously with the decisions being made, while the final legislation was formally published in the *Official Journal of the European Union* on the 30th of January 1997, 42 days after the legislation had been agreed upon and signed. Access to a full timeline of the events for this example, including online decision documents, can be located at
http://eur-lex.europa.eu/legal-content/EN/HIS/?uri=CELEX:51996AP0380&qid=1402641232260

construct the list. Table 2.1 also shows key dates at which the first and second political institutions announced their position to accept (or amend) the proposal, the signature date and the final publication date. The URL hyperlinks, embedded in the reference for each legislation, show that all of the key dates, documents and discussions are freely available to any investor who wishes to find such information. A rational investor, who benefits economically from such information, is expected to be able to locate this information in a similar manner to that performed by the author of this thesis.

2.1.5 Co-decisions, Signatures and Legal-Linguistic Finalisation

As stated previously, both political institutions must vote to agree upon a legislative proposal for it to pass into law. However, mutual agreement on a text does not represent the finalisation of the legislative procedure, as there are additional stages that occur prior to the text being signed by both the Parliament and the Council – at which point the text is legally binding. The text upon which the voting and agreement are reached by the Parliament and the Council is only a ‘reasonably finalised’ version of the text (European Parliament, 2012). After agreement on the reasonably finalised text, lawyer-linguists of both political institutions work together to establish a final text (European Parliament et al., 2007, European Parliament, 2012). This is known as the legal-linguistic phase. For each text passed, the Parliament assigns a ‘file coordinator’, while the Council appoints a ‘chef de file’. The two institutions coordinate work, in tandem with experts on the file, to create a base text ahead of the final revision meeting. Changes may only be made to the agreed text with explicit agreement, at the appropriate level, from both the Parliament and the Council (European Parliament et al., 2007).

At the final revision meeting, referred to as the ‘jurist-linguist’ meeting, representatives from Member States, the Parliament, the Council and the Commission read through the whole text and agree upon on the final version in English; other languages are also addressed by Council lawyer-linguists (European Parliament, 2012). This stage of the procedure focuses on defining key legal terms and identification of the firms or sectors that will be impacted by the legislative proposal. At this point, it is difficult to improve the quality of the draft document due to the delicate political compromise needed to reach this stage of the procedure (European Parliament, 2012). However, it must be noted that this stage finalises the boundaries of the legislation, and cements them into the text. While the majority of the impact is expected to occur surrounding the votes of the political institutions, there is still the possibility that legislative proposals may undergo some amendments, which alter the informational content of the proposal, in the weeks prior to the signature date.

TABLE 2.1: A LIST OF RESTRUCTURING LEGISLATION FOR THE EUROPEAN ENERGY UTILITY SECTOR

This table presents a list of 54 regulatory events expected to affect European energy utilities. The table presents the legislation title, reference and restructuring stream for each legislation. Dates regarding the key stages of the legislative procedure are also presented. The reference is comprised of the legislation type and its identification number. The reference also contains embedded URL hyperlinks which provide access to a full timeline of the legislative procedure.

Legislation Title	Reference	Restructuring Stream	1st Position (Agree/Amend)	2nd Position (Agree)	Signature Date	Publication Date
Common rules for the internal market in electricity	Directive 96/92/EC	Internal Energy Market	11 Dec 1996	19 Dec 1996	19 Dec 1996	30 Jan 1997
Energy labelling of household dishwashers	Commission Directive 97/17/EC	Energy Efficiency			16 Apr 1997	7 May 1997
Energy labelling of household lamps	Commission Directive 98/11/EC	Energy Efficiency			27 Jan 1998	10 Mar 1998
Common rules for the internal market in natural gas	Directive 98/30/EC	Internal Energy Market	30 Apr 1998	11 May 1998	22 Jun 1998	21 Jul 1998
Energy efficiency requirements for ballasts for fluorescent lighting	Directive 2000/55/EC	Energy Efficiency	30 May 2000	5 Jul 2000	18 Sep 2000	1 Nov 2000
Renewable energy: the promotion of electricity from renewable energy sources	Directive 2001/77/EC	Renewable Energies	4 Jul 2001	7 Sep 2001	27 Sep 2001	27 Oct 2001
Community energy efficiency labelling programme for office equipment	Regulation (EC) No 2422/2001	Energy Efficiency	30 May 2001	3 Oct 2001	6 Nov 2001	15 Dec 2001
Energy labelling of household air-conditioners	Commission Directive 2002/31/EC	Energy Efficiency			22 Mar 2002	3 Apr 2002
Energy labelling of household electric ovens	Commission Directive 2002/40/EC	Energy Efficiency			8 May 2002	15 May 2002
Energy performance of buildings	Directive 2002/91/EC	Energy Efficiency	10 Oct 2002	25 Nov 2002	16 Dec 2002	4 Jan 2003
Statute for executive agencies to be entrusted with certain tasks in the management of Community programmes	Council Regulation (EC) No 58/2003	Energy Efficiency		5 Jul 2001	19 Dec 2002	16 Jan 2003
Establishing the European Community Energy Star Board	Commission Decision 2003/168/EC	Energy Efficiency			11 Mar 2003	12 Mar 2003
Promotion of the use of biofuels or other renewable fuels for transport	Directive 2003/30/EC	Renewable Energies	12 Mar 2003	8 Apr 2003	8 May 2003	17 May 2003
Rules of procedure of the European Community Energy Star Board	Commission Decision 2003/367/EC	Energy Efficiency			15 May 2003	21 May 2003
Cross-border exchanges in electricity	Regulations (EC) No 1228/2003	Internal Energy Market	4 Jun 2003	16 Jun 2003	26 Jun 2003	15 Jul 2003
"Intelligent Energy for Europe" programme (2003-2006)	Decision No 1230/2003/EC	Energy Efficiency	13 May 2003	16 Jun 2003	26 Jun 2003	15 Jul 2003
Internal market for energy (until March 2011)	Directive 2003/54/EC	Internal Energy Market	4 Jun 2003	16 Jun 2003	26 Jun 2003	15 Jul 2003
Internal market for natural gas	Directive 2003/55/EC	Internal Energy Market	4 Jun 2003	16 Jun 2003	26 Jun 2003	15 Jul 2003
Trans-European energy networks	Decision No 1229/2003/EC	Internal Energy Market	4 Jun 2003	16 Jun 2003	26 Jun 2003	15 Jul 2003
Greenhouse gas emission allowance trading scheme	Directive 2003/87/EC	Internal Energy Market	2 Jul 2003	22 Jul 2003	13 Oct 2003	25 Oct 2003
European Regulators Group for Electricity and Gas	Commission Decision 2003/796/EC	Internal Energy Market			11 Nov 2003	14 Nov 2003
Cogeneration based on a useful heat demand in the internal energy market	Directive 2004/8/EC	Energy Efficiency	18 Dec 2003	26 Jan 2004	11 Feb 2004	21 Feb 2004
Rules applicable to procurement by entities operating in the water, energy, transport and postal services sectors until 2016	Directive 2004/17/EC	Internal Energy Market	29 Jan 2004	3 Feb 2004	31 Mar 2004	30 Apr 2004
Security of supply of natural gas	Council Directive 2004/67/EC	Security of Supply		20 Apr 2004	26 Apr 2004	29 Apr 2004
Ecodesign requirements for energy-using products	Directive 2005/32/EC	Energy Efficiency	13 Apr 2005	23 May 2005	6 Jul 2005	22 Jul 2005
Conditions for access to the gas transmission networks	Regulation (EC) No 1775/2005	Internal Energy Market	8 Mar 2005	12 Jul 2005	28 Sep 2005	3 Nov 2005
Security of supply of electricity	Directive 2005/89/EC	Security of Supply	5 Jul 2005	1 Dec 2005	18 Jan 2006	4 Feb 2006
Energy end-use efficiency and energy services	Directive 2006/32/EC	Energy Efficiency	13 Dec 2005	14 Mar 2006	5 Apr 2006	27 Apr 2006
Strategic Oil Stocks	Council Directive 2006/67/EC	Security of Supply			24 Jul 2006	8 Aug 2006
Trans-European energy networks	Decision No 1364/2006/EC	Internal Energy Market	4 Apr 2006	24 Jul 2006	6 Sep 2006	22 Sep 2006
Competitiveness and Innovation Framework Programme (CIP) (2007-2013)	Decision 1639/2006/EC	Energy Efficiency	1 Jun 2006	12 Oct 2006	24 Oct 2006	9 Nov 2006

Table 2.1 (continued)

Legislation Title	Reference	Restructuring Stream	1st Position (Agree/Amend)	2nd Position (Agree)	Signature Date	Publication Date
Energy efficiency of office equipment: The Energy Star Programme (EU - US)	Council Decision 2006/1005/EC	Energy Efficiency			18 Dec 2006	28 Dec 2006
Rules for the granting of Community financial aid in the field of the trans-European transport and energy networks	Regulation (EC) No 680/2007	Energy Efficiency	22 Mar 2007	23 May 2007	20 Jun 2007	22 Jun 2007
Framework for the setting of ecodesign requirements for energy-using products	Directive 2008/28/EC	Energy Efficiency	11 Jul 2007	3 Mar 2008	11 Mar 2008	20 Mar 2008
Transparency of gas and electricity prices	Directive 2008/92/EC	Internal Energy Market	17 Jun 2008	25 Sep 2008	22 Oct 2008	7 Nov 2008
Adapting a number of instruments subject to the procedure laid down in Article 251 of the Treaty to Council Decision 1999/468/EC, with regard to the regulatory procedure with scrutiny	Regulation (EC) No 1137/2008	Energy Efficiency	18 Jun 2008	25 Sep 2008	22 Oct 2008	21 Nov 2008
Ecodesign requirements for fluorescent lamps, for high intensity discharge lamps, and for their ballasts	Commission Regulation (EC) No 245/2009	Energy Efficiency			18 Mar 2009	24 Mar 2009
Promotion of the use of energy from renewable sources	Directive 2009/28/EC	Renewable Energies	17 Dec 2008	6 Apr 2009	23 Apr 2009	5 Jun 2009
Internal market in gas (from March 2011)	Directive 2009/73/EC	Internal Energy Market	22 Apr 2009	25 Jun 2009	13 Jul 2009	14 Aug 2009
Internal market in electricity (from March 2011)	Directive 2009/72/EC	Internal Energy Market	22 Apr 2009	25 Jun 2009	13 Jul 2009	14 Aug 2009
Agency for the Cooperation of Energy Regulators	Regulation (EC) No 713/2009	Internal Energy Market	22 Apr 2009	25 Jun 2009	13 Jul 2009	14 Aug 2009
Cross-border exchanges in electricity (from 2011)	Regulation (EC) No 714/2009	Internal Energy Market	22 Apr 2009	25 Jun 2009	13 Jul 2009	14 Aug 2009
Conditions for access to the natural gas transmission networks	Regulation (EC) No 715/2009	Internal Energy Market	22 Apr 2009	25 Jun 2009	13 Jul 2009	14 Aug 2009
Stocks of crude oil and petroleum products (from 2012)	Council Directive 2009/119/EC	Security of Supply	22 Apr 2009	12 Jun 2009	14 Sep 2009	9 Oct 2009
Framework for the setting of ecodesign requirements for energy-related products	Directive 2009/125/EC	Energy Efficiency	24 Apr 2009	25 Sep 2009	21 Oct 2009	31 Oct 2009
Labelling of tyres with respect to fuel efficiency and other essential parameters	Regulation (EC) No 1222/2009	Energy Efficiency	20 Nov 2009	25 Nov 2009	25 Nov 2009	22 Dec 2009
Community financial aid to trans-European networks	Regulation (EC) No 67/2010	Internal Energy Market	24 Nov 2009	26 Nov 2009	30 Nov 2009	30 Jan 2010
Energy performance of buildings	Directive 2010/31/EU	Energy Efficiency	14 Apr 2010	18 May 2010	19 May 2010	18 Jun 2010
Indication by labelling and standard product information of the consumption of energy and other resources by energy-related products	Directive 2010/30/EU	Energy Efficiency	14 Apr 2010	19 May 2010	19 May 2010	18 Jun 2010
Security of supply of natural gas	Regulation (EU) No 994/2010	Security of Supply	21 Sep 2010	11 Oct 2010	20 Oct 2010	12 Nov 2010
A comparative methodology framework for calculating cost-optimal levels of minimum energy performance requirements for buildings and building elements	Commission Delegated Regulation (EU) No 244/2012	Energy Efficiency			16 Jan 2012	21 Mar 2012
Competitiveness and Innovation Framework Programme (2007-2013)	Regulation (EU) No 670/2012	Energy Efficiency	5 Jul 2012	10 Jul 2012	11 Jul 2012	31 Jul 2012
Stepping up EU energy efficiency efforts	Directive 2012/27/EU	Energy Efficiency	12 Sep 2012	4 Oct 2012	25 Oct 2012	14 Nov 2012
Guidelines for trans-European energy infrastructure	Regulation (EU) No 347/2013	Internal Energy Market	12 Mar 2013	21 Mar 2013	17 Apr 2013	25 Apr 2013

Once a proposal has been agreed upon by both the Parliament and the Council, the two political institutions agree upon a common presentation of the text, and hold joint press conferences and press releases to announce the successful outcome of the legislative process. Following the adoption of the final text, the act is placed on the public register, sent to the capitals of the Member States, adopted by the Council and submitted for signing by the Presidents and Secretaries-General of both the Parliament and the Council. This signature date represents the third key stage of the ordinary legislative procedure, examined using an event study approach. The Presidents shall, as far as possible, sign the text together in a joint ceremony, organised on a monthly basis in the presence of the media. The monthly organisation of the meeting and signing of the document can be considered merely ceremonial. From an efficient market perspective, rational investors will have already incorporated the informational content and cash flow implications of the final text into stock prices at an earlier stage of the procedure. For reasons above, we must be aware that any impact surrounding the signature date may be capturing any changes in key definitions or legal terms during the finalisation stages. The jointly signed text is submitted for publication in *The Official Journal of the European Union*, the central law archive for European legislation. Publication in *The Official Journal of the European Union* normally occurs within two months of adoption (European Parliament et al., 2007).

Assuming market efficiency, investors will revalue energy utilities' stocks today based on perceived changes to future cash flows as a result of regulatory changes (Schwert, 1981). When information is anticipated or becomes public knowledge, information is immediately impounded into stock prices; therefore, any sudden change in value implies that the market has changed its assessment of future cash flows (Klassen and McLaughlin, 1996). In the case of the ordinary legislative procedure, see Sections 2.1.1 to 2.1.5, there are potentially four important dates where investors are likely to react to informational content: the announcement of the 1st position (usually Parliament), the announcement of the 2nd position (usually Council), the signature date and the publication date. This thesis tests all four stages as Griffin et al. (2015) argue that investors may not respond to information for numerous reasons, including 1) remote and uncertain consequences for the firm regarding the long-term nature of increased investment risk, 2) the expectation of full mitigation from government policies or 3) the ability to mitigate risk individually. Chapter 6 posits that the market reaction will occur surrounding the announcement of the two positions, as the latter signing and publication dates contain no new informational content for an investor. The four stages are summarised in Figure 2.2.

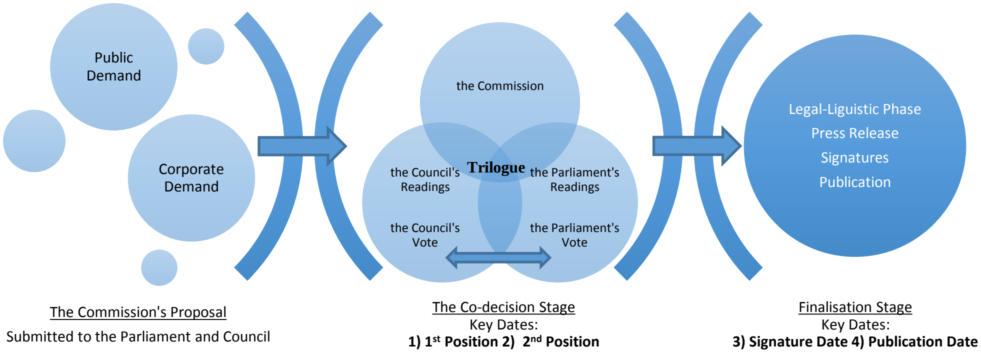


FIGURE 2.2: THE TIMELINE OF A LEGISLATION'S PROPOSAL

This figure presents the timeline of the typical ordinary legislative procedure. The Commission initiates the proposal from public or corporate demand. During the co-decision stage, the Parliament and the Council independently review the proposals and vote to adopt, amend or reject. Trilogues between the Parliament, the Council and the Commission facilitate an early decision. The co-decision stage can last up to three readings (see Figure 2.1). If accepted, the proposal enters the finalisation stage where the document is signed and published.

Having extensively outlined the legislative procedure of the EU, this chapter continues by describing four restructuring streams which relate to the European energy utility sector. Each stream is relatively distinct from one another, and therefore is likely to have a unique impact on the sector.

2.2 EU Legislation and the Four Restructuring Streams

Traditionally, European energy supply was based on national and regional markets with vertically integrated companies that could produce, transmit and distribute energy to nearby consumers with natural, regional monopolies. Since 1987, the EU has begun to make progress towards greater European integration, allowing the free movement of goods, persons, services and capital across European borders. The overall objective was to increase transnational competition within the EU, thereby exposing inefficiencies in firm operations and slowly phasing out inefficient firms. Consequently, there have been a large number of legislative acts establishing common rules for a single European internal market for energy, replacing the national- and regional-based structures for the energy supply (Newbery, 2002, Jamasb and Pollitt, 2005, Green, 2006). This gradual approach was designed to enable the sector to adjust in a flexible and orderly manner to its new competitive environment.

The removal of national barriers created an international market where energy utilities can compete on price, services and market share. In a regulated system, the demand for energy, such as electricity, was relatively easy to predict as utilities had exclusive rights to regions. When faced with competition, utilities must accommodate the additional challenge of determining their energy supply based on energy demand and competitors' energy supplies. In addition, the energy sector has been exposed to a number of environmental objectives aimed at reducing carbon emissions through policy and market mechanisms, such as the EU ETS

Another major EU-led reform thrust that has built up particular momentum is related to the environmental objectives of the sector, or the 'greening' of the energy supply. This has focused on reducing demand through energy efficiency legislation and through policies that promote renewable energies. In addition to the liberalisation and environmental policies, EU utilities have also been subject to a range of legislation related to security of energy supply. The following sections outline four distinct restructuring streams impacting the energy sector. Propositions regarding their expected impacts are mostly addressed in the literature review (Chapter 3).

The liberalisation and environmental objectives of the energy sector can be divided into four distinct streams, as illustrated in Figure 2.3. The liberalisation objectives contain one restructuring stream, the *Internal Energy Market*, which encompasses deregulation of national and EU energy markets and frontiers and establishes independent regulatory bodies. The decarbonisation objectives include two streams: 1) *Energy Efficiency*, which reduces end-user demand, and 2) *Renewable Energies*, which increases the use of biofuels and renewable energy sources in electricity generation and sets targets for the electrification of other European sectors. The final category includes one stream, *Security of Supply*. This stream is designed to offset or diminish the harmful effects from difficulties securing crude oil and petroleum products for both energy and economic activity, but also outlines steps taken to ensure the security of the electricity and natural gas supply within the EU.

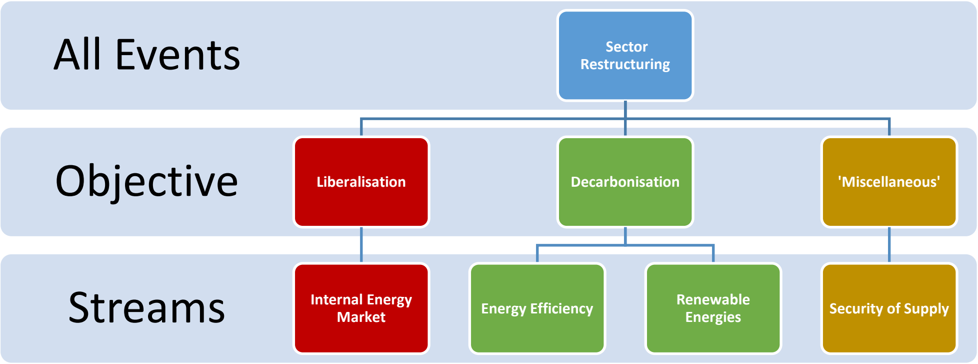


FIGURE 2.3: HIERARCHY OF RESTRUCTURING CATEGORIES AND STREAMS.

This figure illustrates the hierarchy of the four restructuring streams. The liberalisation objective contains one stream (Internal Energy Market); the decarbonisation objective is comprised of two streams (Energy Efficiency and Renewable Energies); a miscellaneous objective contains the Security of Supply stream.

As mentioned earlier, a full list of the legislation regarding the restructuring of the energy sector is shown in Table 2.1, which also categorises the legislation by restructuring stream. The table shows that the Internal Energy Market and Energy Efficiency streams have the greatest amount of legislation. The Internal Energy Market stream was clustered in three periods, pre-2000, 2003 and 2009, with sporadic legislation enacted between 2003 and 2009. The Energy Efficiency stream is spread through time. The Renewable Energies and Security of Supply streams have the least amount of legislation, and are also spread through time. The following sections address each restructuring stream, and their potential impacts on the energy sector.

2.2.1 Liberalisation Stream

The liberalisation objectives of the energy sector are congruent with the overall goals of the EU community, namely, to progressively create internal markets for specific sectors, removing all internal frontiers. The Single European Act (1987), the first major revision of the Treaty of Rome (1957), aimed to allow the free movement of goods, persons, services and capital across European borders. The liberalisation stream focuses on removing frontiers to gradually establish internal markets for electricity and natural gas, creating a competitive energy market. The removal of international barriers allows European energy utilities to create much larger customer bases throughout Europe. Nonetheless, it also exposes the energy utilities to potential reductions in demand, as competitors from other EU countries can now compete for incumbents' domestic customer market segments. This competitive market was expected to increase efficiency of production, transmission and distribution by phasing out inefficient incumbent energy utilities. A gradual approach to introducing EU-level competition was chosen, designed to enable the sector to adjust in a flexible and ordered manner to its new competitive environment. The legislation seeks to ensure that the transmission system of energy is transparent and non-discriminatory. This is achieved by creating independent transmission operations which prevent abnormally high or low tariffs or discriminatory practices.

Within the EU legislation to liberalise the energy sector, there were three major reform initiatives, referred to as the 'three packages'. The three packages represent multiple related regulatory or legislative changes that are argued to have significantly changed the infrastructure of the European electricity and gas sectors, and represent the most anticipated legislative changes. The three packages are as follows.

The First Packages: the first packages for electricity[16] and gas[17] were published in 1997 and 1998, respectively. The packages represent the first attempts to remove national barriers in the EU. The packages resulted in only minor liberalisation of the energy sector and

---

[16] Directive 1996/92/EC. Note, this legislation was agreed upon in December 1996 (see footnote 15).

[17] Directive 1998/30/EC

minor commitments from Member States; only high-volume commercial consumers were able to switch suppliers (Eikeland, 2011). The first packages provided no clear rules on the transmission of energy through existing networks but required revenue unbundling of vertically integrated companies, recording generation and retail revenue separately. Regardless, vertically integrated companies still possessed monopolies over retail networks and therefore were able to survive any wholesale price shocks, while non-integrated companies became bankrupt (Jamasb and Pollitt, 2005). This provided an economic incentive for non-integrated companies to integrate generation and distribution by asset acquisition or merging. As a result, there was relatively little competition in the EU energy sector.

The Second Packages: implementing the first packages were argued to have resulted in a variety of benefits, including increased efficiency, price reductions, higher standards of service and increased competitiveness.[18] However, the sector still lacked concrete provisions which ensured a level playing field in generation and reduced the risk of market dominance. Further, Member States' idiosyncrasies caused delays in restructuring implementation, allowing vertically integrated utilities to continue to impede fair competition (Eikeland, 2011, Erdogdu, 2014). The second packages[18] for electricity and gas were published in 2003, with the objective of creating a truly open market in the EU, which allowed consumers to freely choose suppliers and suppliers to freely deliver to customers across Europe. The second packages were designed to 1) counter dominant and predatory behaviour of vertically integrated companies, and 2) continue to open borders to encourage national and international competition. By July 2007, the second packages aimed to achieve 1) *legal* unbundling of transmission system operators (TSO) and distribution system operators (DSO) from the remainder of the industries, 2) free entry to generation, 3) monitoring supply competition, 4) a fully open market enabling household customers to switch suppliers,[19] 5) promotion of renewable energy fuel sources, 6) strengthening of the role of the market regulators, 7) a single European market for energy and 8) regulated access to energy grids (Jamasb and Pollitt, 2005, Eikeland, 2011). The rationale was that a legally independent transmission operator would charge equitable prices to competing generators, increasing transparency of pricing. Further, a fully open market would allow consumers to freely choose energy suppliers.

The Third Packages: the third packages,[20] published in 2009, were designed to address the unachieved liberalisation objectives of the second packages (Eikeland, 2011). The

---

[18] Directive 2003/54/EC; Directive 2003/55/EC

[19] Non-household customers could freely choose suppliers from 1 July 2004; residential from 1 July 2007.

[20] Directive 2009/72/EC; Directive 2009/73/EC

legislation highlighted that the legal and functional unbundling of vertically integrated companies did not lead to effective unbundling of TSOs. More than two-thirds of the European generation market share was owned by eight large utilities (Jamasb and Pollitt, 2005). Such ownership structure resulted in continued misuse of networks, with competing energy generators complaining of unfair grid access and network fees (ACER, 2013). A clear and effective way to solve the discriminatory network access obstacle was the unbundling of *ownership* at the transmission level for vertically integrated companies, separating transmission and generation companies into two separate entities. Accordingly, the same person was no longer allowed to be a member of management boards for a transmission company and perform any function for a generation or supply company. Further, the legislation also proposed the modernisation of distribution networks into ‘smart grids’, encouraging decentralised generation and energy efficiency. Finally, the third packages addressed the issue that national regulators lacked independence from government, and had insufficient powers and discretion to effectively regulate the sector.

To ensure restructuring legislation were enforced, market monitoring agencies were established to act as independent regulatory authorities. In 2003 and 2005,[21] the fair rules for cross-border exchanges in electricity and gas were established. The European Regulatory Group for Electricity and Gas (ERGEG)[22] was established as a temporary solution to address failures of fair grid access. ERGEG sought to ensure that EU-level legislation were consistently applied, facilitating independent regulatory authority, consultation, coordination and cooperation between regulatory bodies within Member States. Despite ERGEG’s positive contribution, criticisms of discriminatory access to networks continued. As a result, in 2009, the Agency for the Cooperation of Energy Regulators (ACER)[23] was established in conjunction with the third package. ACER monitors regional cooperation and executes tasks for the European Network of Transmission System Operators for Electricity (ENTSO-E) and the European Network of Transmission System Operators for Gas (ENTSO-G) ensuring operation transparency and efficiency; explained further below.

The membership groups,[24] ENTSO-E and ENTSO-G, ensure optimal cross-border management and trading of energy, set non-discriminatory rules for grid access and produce community-wide 10-year network development plans regarding security of the energy supply. To facilitate access to networks, various legislation defined guidelines and compensation for

---

[21] Regulation 1228/2003; Regulation 1775/2005

[22] Commission Decision 2003/796/EC

[23] Regulation 713/2009

[24] Regulation 714/2009; Regulation 715/2009

hosting cross-border transmissions to facilitate fair access. Yet, in 2013, energy generators, including renewable generators, still complained about unequal access to transmission grids and unfair transmission fees (ACER, 2013). To address the issue, a final piece of legislation amalgamated and repealed all previous legislation.[25] The legislation also defined the expected financial contribution to EU-level network investment and compensation for international transmission in the energy sector. This legislation highlighted that, to that point, there were still isolated energy markets in the EU and that some Member States still failed to meet interconnectivity targets.

In summary, a variety of legislative changes relating to sector liberalisation have been published over the last two decades. Sectors are becoming increasingly liberalised despite resistance from big utilities. Further, regulatory agencies have been established to counteract sector domination by some energy utilities. The TSOs of the EU energy sector were, and still are, relatively regulated. However, the 2013 regulations acknowledged that the EU energy market was still not fully liberalised and unfair access prevailed. What is important from a financial market perspective is that regulations are regularly strengthening the drive towards a single energy market, and EU-level regulatory agencies are increasingly being given additional powers which will negatively impact the dominant utilities in Europe, affecting operating revenue and future cash flows.

The discussion above sets the general framework and context of liberalisation; however, it overlooks some important details and exceptions. One important example is that some utilities are exempt from the legislative changes, namely, some natural gas utilities and small utilities. In contrast to encouraging high levels of competition within the internal market for electricity, the internal market for natural gas also places an emphasis on the interconnection and interoperability of natural gas systems. The interoperability of the systems ensures international gas systems can cooperate and work without special intervention. In contrast to the electricity industry, natural gas legislation also allows storage facilities and long-term contracts – so long as they do not ‘undermine’ the objectives of liberalisation, including the competition rules. Clearly, there is some conflict between long-term contracts and sector competition. Major differences between the electricity and natural gas legislation arise from the fact that electricity cannot be stored, whereas natural gas can be stored in a number of ways. Further, there are derogations established for Member States which have no gas infrastructure, or a gas infrastructure less than 10 years old – this caveat suggests that only mature gas networks will be affected by liberalisation. For small utilities,

---

[25] Regulation 347/2013

provisions are made to avoid disproportionate financial and administrative burdens. Member States could exempt small distribution companies from the legal distribution unbundling. This is important, as smaller distributors will not be affected by these legislative changes, while large distributors are exposed to regulatory risk. Accordingly, there should be little to no impact of Internal Energy Market legislation on small utilities and natural gas utilities.

Beyond sector liberalisation, a second theme which has gained prominence in recent years is the 'greening' of the energy supply. Environmental objectives aim, by 2020, to boost renewable energy use by 20%, reduce greenhouse gas emissions by 20% and achieve a 20% increase in energy efficiency, commonly referred to as the '2020 × 3' or '20-20-20' targets. There are two methods to achieving climate change objectives: the economic approach and the regulatory approach (Dobes et al., 2014). The latter approach prescribes policies or forbids processes, products and activities. The regulatory approach is the major concern of this thesis. The next two sections examine the legislation enacted to achieve these targets.

2.2.2 Energy Efficiency Stream

The general scientific consensus is that there needs to be significant reductions in greenhouse gas (GHG) emissions in order to limit the likelihood of the extreme impacts of climate change (Dobes et al., 2014). The electricity industry is a natural place to begin decarbonising the economy, as it can be achieved at lower cost and with less behavioural and structural change relative to other sectors (Newbery, 2016). The Energy Efficiency stream was designed to reduce the rate of growth of internal energy consumption by encouraging the rational and economic use of energy, without jeopardising social and economic growth objectives. Ultimately, the EU is attempting the stabilisation of total carbon dioxide emission, whilst taking into account the growth needs of Member States. Between 1994 and 2014, the population of the EU grew, on average, by about 1.3 million people per year.[26] A large proportion of GHG emissions, particularly carbon dioxide comes from fossil-fuel combustion and is the focus of most academic papers (Dobes et al., 2014). As late as 2010, 67.2% of the worlds' electricity production was from generation plants burning fossil fuels (IEA, 2012). As electricity demand is considered relatively inelastic (Oberndorfer, 2009a), the expectation is that increasing population also results in increasing gross emissions. As such, it is possible that gross GHG emissions may rise. Therefore, the relevant variable when measuring GHG reduction is focusing on emissions per capita (Dobes et al., 2014). The objective of the

---

[26] Data extracted from *EUROPA:* http://ec.europa.eu/eurostat/statistics-explained/index.php/Population_and_population_change_statistics#EU-28_population_continues_to_grow

Energy Efficiency stream is to reduce energy consumption at the user end of the energy supply chain. The Energy Efficiency stream was implemented in two ways.

First, the Energy Efficiency stream aimed to encourage manufacturers to make more energy-efficient appliances by informing the public of the energy consumption of common electrical household appliances. The Energy Efficiency legislation systematically identified energy-intensive end-user appliances and required comprehensive labelling of consumption. The labelling scheme implemented a standardised measure of energy efficiency, rating energy consumption. Appliances included space heating, air conditioning units, electric ovens, lights, washer, driers, refrigerators and freezers. Legislation also set a maximum electricity consumption allowed per appliance. The rationale behind the stream was that end users, when faced with choices of similar appliances, would favour the appliance which consumed the least energy. The incentive for end users was lowering their energy consumption and making economic savings on annual fuel bills over time.

The second objectives of the Energy Efficiency Stream were related to the energy consumption of buildings, which accounts for 40% of the EU's total energy consumption.[27] The legislation required objective information on the energy characteristics of buildings to help improve the transparency of the property market and encourage energy efficiency. In an effort to reduce emissions, the legislation required that buildings were to be billed for heating, air conditioning and hot water costs based on actual consumption. Similar to the appliance legislation above, occupants of the home were expected to self-regulate their own consumption and be incentivised through economic savings on fuel bills. Property legislation had a differential impact on old buildings compared with new buildings. Old buildings were to be improved through insulation, whereas new buildings were subjected to more regulation with the intention of being carbon-zero by 2020. Further, any new buildings must be fitted with thermal insulation tailored to the local climate.

In summary, the energy efficiency legislation represents a change in the total end-user demand for energy in the EU. The expectation is that energy demand in Europe will fall by 10% to 20% by 2050 as a result of legislative changes (Delarue et al., 2011). A reduction in energy demand will therefore affect operational performance of utilities, affecting future cash flows and, ultimately, sector valuation. Beyond the Energy Efficiency stream, the environmental objectives of sector restructuring also include the Renewable Energies restructuring stream, which had distinct objectives compared to the Energy Efficiency stream.

---

[27] Directive 2010/31/EU.

2.2.3 Renewable Energies Stream

Promotion of renewable energy was important, as the EU recognised that renewables represented an exploitable source of energy which could contribute to the objectives of environmental protection and help achieve sustainability targets (Kanellakis et al., 2013). Similar to the Energy Efficiency stream, the Renewable Energies stream also focused on reducing carbon emissions in the EU. However, the stream focused on the supply side of energy utilities and the market itself. In 2001, Directive 2001/77/EC set an indicative target of 22.1% of gross electricity consumption from RES by 2010. In 2003, Directive 2003/30/EC set national indicative targets for the increased use of biofuels in transport, at 5.75% by 2010. In 2007, the EU endorsed a mandatory target of 20% share of final energy consumption from RES and a 10% minimum biofuel target in transport petrol and diesel consumption by 2020. Both targets led to the RES Directive 2009/28/EC (Kanellakis et al., 2013). Emission reductions were expected to be achieved through increased use of renewable energy sources in electricity generation and transport.

The typical electricity market design assumes thermal or hydro plants would supply the bulk of services (Ahlstrom et al., 2015). The low marginal cost of RES and nuclear energy means these generators can sometimes out-bid all gas- and coal-fired generation, especially during periods of low-demand (Green and Vasilakos, 2010). This has been magnified by the renewable energy legislation, which focused on providing grid priority for electricity generated from RES and biofuels.[28] Grid priority ensured that renewable energy generators were able to sell and transmit electricity, in accordance with connection rules, whenever the renewable energy source (solar, wind, hydro, etc.) became available. Put simply, they were afforded first access to the grid ahead of combustion fuel generators. This grid priority was uncapped, allowing the renewable generators to utilise their maximum capacity,[29] reducing the number of operating hours for conventional generators as wind and solar tend to generate the greatest amount of energy during the daytime, coinciding with the peak hours which were historically the most profitable hours.

Equilibrium models and empirical evidence has shown that an increasing share of renewable generation, with an effective marginal cost of zero, depresses day-head and wholesale prices (Green and Newbery, 1992, Newbery, 1998, Green and Vasilakos, 2010, Ahlstrom et al., 2015, FTI-CL Energy, 2015, Newbery, 2015). Recent empirical evidence shows that the estimated merit order effects range from 0.97 to 2.27 €/MWh for wind and

---

[28] Directive 2001/77/EC

[29] Directive 2009/28/EC

from 0.84 to 1.37 €/MWh for solar photovoltaic for each additional gigawatt of installed capacity, where the overall impacts range from 2 to 13 €/MWh (Cludius et al., 2014). Recent peaks in wholesale prices have declined from 14 €/MWh in 2008 to a premium of only 3 €/MWh in 2013 (The Economist, 2013b).

Out-of-market RES support schemes, such as feed-in tariffs and premiums, also incentivise RES production in hours where power prices are below avoidable costs. RES generators continue to produce electricity as they can claim feed-in-tariff subsidies (Fanone et al., 2013), creating further market distortions (FTI-CL Energy, 2015). There is a real risk that energy prices will converge towards the marginal cost of (effectively) zero for increasing periods of time (Riesz and Milligan, 2015). The RES support schemes have led to a rapid uptake of renewables, which must be matched by a parallel exit of conventional technology from the system. Without sufficient exit, there will be over-capacity in the EU energy system, which will further depress prices and contribute to the ongoing investment challenge.

A ‘missing money’ issue arises when expected net revenues from sales of energy and ancillary services provide inadequate incentives for investment in new generating capacity, or do not fully account for the opportunity cost of incremental demand or operating reserves during periods of scarcity (Hogan, 2005, Joskow, 2013). Large generators are designed to work at near maximum capacity, finding it difficult and costly to scale back operations (Green and Vasilakos, 2010). Some generators are incentivised to place negative bids into the wholesale market during low residual loads, as turning off would incur additional costs and risks (DECC, 2010, Ahlstrom et al., 2015). These phenomenon of negative pricing where generators pay, rather than be paid to deliver energy, indicates the system requires flexibility improvements (Hogan, 2005; Riesz and Milligan, 2015). These issues were anticipated by the EU, as the 2009 legislation highlighted that grid reliability may be compromised and appropriate financial compensation may be given to energy producers.[29] Thus, measures were in place to protect disproportionally affected utilities.

The current market framework is unlikely to remunerate the fixed-costs of power stations and does not produce enough expected life-cycle net revenues to incentivise investment in generating capacity (Joskow, 2013, Robinson, 2015). As prices are disconnected from opportunity costs, lower wholesale prices leave incumbents unable to recoup the necessary return on thermal investments and new entrants cannot establish market capitalisation at the necessary level to finance new base-load assets without additional payments beyond the energy market (Caldecott and McDaniels, 2014, Newbery, 2015, Robinson, 2015). Reduced investment lowers the necessary properties to handle system failures and ensure security of supply (Energinet, 2015), especially if variable RES is not supported by a constant and reliable energy source (Edenhofer et al., 2011). This implies large generators are still crucial to preventing power outages and must remain available to generate electricity during brief periods of scarcity (Green and Vasilakos, 2010).

In superficial commentary, The Economist (2013b) argued that the renewable energy objectives were responsible for a decline in market capitalisation of €500 billion. Notably, this claim was made without any substantial empirical evidence beyond anecdotal observation of share prices, and also overlooked the fact that the grid priority legislation was agreed upon in 2001,[28] and was to be put into force no later than 27th October 2003. In a rational market, it is unlikely that investors would respond, in 2008, to such outdated legislation.

Where market valuation is based on investors' perception, it is important to consider the social benefits of increased renewable objectives. Social investing is an increasingly important component of equity markets and determining equilibrium asset prices. More than ever, shareholders are monitoring the actions of managers regarding the social responsibility of the company (Ansar et al., 2013). In addition to the social implications of lower emissions and a cleaner environment, the increased use of renewables was expected to create local employment, contribute to the security of supply and enable the EU to rapidly meet its Kyoto targets.[29]

The renewable energies legislation contained a further objective which was expected to directly benefit energy utilities, thus increasing valuation. In particular, the renewable energies legislation[29] focused on increasing technological improvements within energy utilities and, more importantly, setting targets for the electrification of neighbouring sectors. The purpose of the objective was to reduce the EU's reliance on imported energy (primarily oil), but to also create a new potential market for energy. Specifically, the EU has set a mandatory target for the overall share of energy from renewable sources (both biofuel and viable alternatives) for the transport sector. Transport fuel accounts for more than 30% of final energy consumption,[30] and is expanding as the EU community expands. Additionally, road transport accounts for 84% of transport-related CO_2 emission.[30] The 2020 targets[29,30] for the transport sector were 1) a minimum of 20% of conventional fuels being substituted with alternative fuels, and 2) a minimum of 10% of energy being derived from renewable energy sources, applicable across all Member States. The renewable energy legislation also focused on decentralising renewable energy technologies, which was expected to increase the utilisation of local energy sources, increase the energy supply and reduce energy transmission losses – increasing the overall efficiency of energy generation. Naturally, such a rapid

---

[30] Directive 2003/30/EC

expansion of renewable energy requires labour, creating local jobs for EU residents[29] – also expected to increase value through corporate social responsibility.

2.2.4 Security of Supply Stream

Predating liberalisation and decarbonisation objectives, an existing EU policy pillar was ensuring security of energy supply (Kanellakis et al., 2013). The Security of Supply stream focused on diminishing the harmful effects from difficulties in securing crude oil and petroleum products, for both energy and economic activity. The legislation was based on the premise of dwindling supplies of oil reserves coupled with a growing global consumption of oil, potentially leading to difficulties in maintaining the energy supply within Europe. Any difficulties in the energy supply can impact economic activity and the growth of the EU (Costantini et al., 2007). Such disruptions pose serious community-level risks to the EU; therefore legislation ensured that the EU was in a position to offset any harmful effects (Dorian et al., 2006).

The legislation requires Member States to maintain minimum levels of crude oil reserves and petroleum products, determined by various levels of inland consumption (Kanellakis et al., 2013). The intention was to release strategic reserves of oil into the international market in the event of a supply disruption that required market level intervention to bridge the supply gap (DECC, 2013). Supply gaps could arise through a variety of situations, including, but not limited to, price developments in the commodity markets or disruptions in the supply of natural gas. Accordingly, the Member States are obliged to maintain minimum stocks of crude oil and/or petroleum products, distribute these stocks to users, impose restrictions on oil consumption and give priority of supplies to certain groups. The overall objective is to grant competent authorities necessary powers to partially regulate oil prices in order to prevent abnormal price rises.[31] Even the slightest imbalance between supply and demand has profound impact on commodity prices, which can reduce real income for oil-importing regions and increase risk-premiums for commodity dependent companies (Costantini et al., 2007). Of this energy reserve, energy utility companies are also given high priority for the consumption of oil stock reserves.

The second major objective of the Security of Supply stream is to reduce the overall financial burden of energy costs on the final consumer.[32] Typically, this has involved establishing one Central Stockholding Entity per Member State, set up for the purpose of holding sufficient supplies of oil stocks.[32] The purpose of the Central Stockholding Entity is

---

[31] Council Directive 73/238/EEC

[32] Council Directive 2009/119/EC

to also allow fuel switching in the case of disruptions, using crude oil and petrol products in energy production.[32] From 2004 and 2006, legislation[33] also began to focus on maintaining the security of supply of natural gas and electricity. Specifically, there is an emphasis on minimum targets for storage of natural gas and establishing long-term supply contracts, which is connected to the Internal Energy Market legislation. For electricity, the legislation focused on maintaining adequate generation capacity, balance between supply and demand, and appropriate interconnections between Member States. The legislation also established bi-lateral oil supply agreements between Member States to ensure backup oil reserves were available when needed as well as the Gas Coordination Group, which facilitated the security of supply of natural gas at the community level in the event of major supply disruptions. To ensure compliance with the Security of Supply objectives, the 2009 legislation[32] established an additional consulting agency comprised of representatives from Member States: the 'Coordination Group' for oil and petroleum products.

Overall, the impact of the Security of Supply stream is expected to primarily impact the price of oil and petroleum. Sections 3.2.3 and 3.2.3.2 discuss the expected impact of oil price risk on oil & gas and energy utility firms. However, if there is a direct long-term and persistent relationship between oil prices and energy utilities, then there is likely to be a shift in sector valuation based on the expected changes of future cash flows as a result of long-term oil price changes. This impact is in excess of any contemporaneous holdings of oil, as the impact affects future revenues rather than current asset holdings. There is also the potential that the Security of Supply stream has little- to no-significant impact on sector returns for two reasons (1) they only have an impact during times of stress in commodity markets (i.e. they tend to be legislations that provide power contingent on certain event and as such may not have cotemporaneous effects) and (2) policies in the field of Renewable Energies, Energy Efficiency, and the Internal Energy Market all implicitly aim at having more secure energy supplies and as such may proxy for the Security of Supply Stream (Kanellakis et al., 2013). However, it is still worth examining legislations singularly focused on Security of Supply as they are an important pillar of EU-level energy policy.

---

[33] Council Directive 2004/67/EC; Directive 2005/89/EC

CHAPTER 3

LITERATURE REVIEW

3.1 Introduction

The following literature review is relevant for Chapters 4 through to 6. The review will help position the empirical studies in the existing bodies of both energy economics and finance literature. This is important, as this chapter will show that the two seemingly related fields have begun to diverge in recent years, integrating different risk factors into the empirical analysis of stock returns. The finance literature in Section 3.2.2 is primarily concerned with identifying significant stock market risk factors, while the energy economics literature in Section 3.2.3 focuses on identifying significant impacts from macroeconomic variables. The purpose of the review is to outline the theoretical justification as to how these two bodies of literature can be reintegrated into a superior asset pricing model for the European energy utility sector, the desire for which arises from demand from energy economic authors such as El-Sharif et al. (2005) and Oberndorfer (2009a). The review also includes literature regarding time-varying risk premia, the impact of regulatory changes and abnormal returns surrounding regulatory events. The literature review proceeds as follows.

Section 3.2 introduces asset pricing models implemented in the empirical analyses of this thesis, including the CAPM and four-factor model from finance literature and the augmented-CAPM from energy economics. Importantly, a summary of empirical results and estimated coefficients, for papers with comparable asset pricing models to this thesis, has been provided in Table 3.1. Section 3.3 includes theory and literature concerning the impact of regulatory changes on stock value, systematic risk and abnormal returns relevant to the four restructuring streams in Sections 2.2. Specifically, Sections 3.3.2 and 3.3.3 outline the liberalisation and environmental policy literature, while Section 3.3.4 introduces theory and the empirical applications of inductive structural break tests. Finally, Section 3.3.5 outlines methodological issues and caveats to empirical analyses of energy utility sectors, including commodity hedging and fuel speculation.

TABLE 3.1: SUMMARY OF EXISTING LITERATURE

This table provides a summary of estimated coefficients from existing finance and energy economics literature. The following table lists the risk factor of interest, the model specification used and the estimated coefficient extracted from the paper. The results are delineated into positive, negative and no significant impacts. The sample's sector/industry is also noted.

Risk Factor	Specification(s)	Est. Coef.	Positive	Sector/Industry	Est. Coef.	Negative	Sector/Industry	No impact	Sector/Industry
Market	**CAPM**	0.99	Fama and French (1995)[D]	Broad market (Big)					
	Augmented CAPM	0.98	Fama and French (1995)[D]	Broad market (Small)					
	Four-Factor	0.98	Faff and Brailsford (1999)	Oil & gas					
		0.97	Fama and French (1993)[D]	Broad market					
		0.96	Fama and French (1997)[D]	Energy					
		0.90	Carhart (1997)	Broad market					
		0.90	El-Sharif et al. (2005)[A,C]	Broad market					
		0.88	Ramos and Veiga (2011)	Oil & gas					
		0.86	Koch and Bassen (2013)	Electricity					
		0.82	Arouri (2011)[B]	Oil & gas					
		0.82	Elyasiani et al. (2011)	Oil & gas					
		0.79	Fama and French (1997)[D]	Utilities					
		0.78	Oberndorfer (2009a)	Electricity					
		0.76	Nandha and Faff (2008)[A]	Oil & gas					
		0.71	Sadorsky (2001)	Oil & gas					
		0.69	Elyasiani et al. (2011)	Utilities					
		0.61	Arouri (2011)	Broad market					
		0.55	Nandha and Faff (2008)[A]	Electricity					
		0.11	Boyer and Filion (2007)	Oil & gas					
Oil	**Augmented CAPM**	0.33	Boyer and Filion (2007)	Oil & gas	-0.09	Nandha and Faff (2008)[A]	Electricity	Koch and Bassen (2013)	Electricity
		0.31	Sadorsky (2001)	Oil & gas	-0.03	Oberndorfer (2009a)	Electricity	Arouri (2011)[B]	Utilities
		0.23	Faff and Brailsford (1999)	Oil & gas				Elyasiani et al. (2011)	Utilities
		0.18	Arouri (2011)[B]	Oil & gas					
		0.16	Manning (1991)	Oil & gas					
		0.15	Nandha and Faff (2008)[A]	Oil & gas					
		0.14	Ramos and Veiga (2011)	Oil & gas					
		0.12	El-Sharif et al. (2005)[A,C]	Broad market					
		0.10	Oberndorfer (2009a)	Oil & gas					
		0.05	Elyasiani et al. (2011)	Oil & gas					
Coal	**Augmented CAPM**				-0.01	Oberndorfer (2009a)	Electricity	Koch and Bassen (2013)[A]	Electricity
Gas	**Augmented CAPM**	0.09	Boyer and Filion (2007)	Oil & gas				Oberndorfer (2009a)	Electricity
								Koch and Bassen (2013)	Electricity

Table 3.1 (continued)

Risk Factor	Specification(s)	Est. Coef.	Positive	Sector/Industry	Est. Coef.	Negative	Sector/Industry	No impact	Sector/Industry
Term	**Augmented CAPM**	0.80	Fama and French (1993)[D]	Broad market	-0.21	Sadorsky (2001)	Oil & gas	Oberndorfer (2009a)	Electricity
	Four-Factor	0.19	El-Sharif et al. (2005)[A,C]	Broad market	-0.03	Boyer and Filion (2007)	Oil & gas		
		0.11	Ramos and Veiga (2011)	Oil & gas					
Carbon	**Augmented CAPM**	0.02	Oberndorfer (2009b)	Electricity	0.05[E]	Koch and Bassen (2013)[A]	Electricity		
Size	**Four-Factor**	0.90	Fama and French (1995)[D]	Broad market (Small)	-0.35	Fama and French (1997)[D]	Energy		
		0.60	Fama and French (1993)[D]	Broad market	-0.20	Fama and French (1997)[D]	Utilities		
		0.57	Elyasiani et al. (2011)	Oil & gas	-0.11	Fama and French (1995)[D]	Broad market (Big)		
		0.23	Elyasiani et al. (2011)	Utilities					
		0.22	Carhart (1997)	Broad markets					
Value	**Four-Factor**	0.98	Elyasiani et al. (2011)	Oil & gas	-0.05	Carhart (1997)	Broad market		
		0.71	Elyasiani et al. (2011)	Utilities					
		0.38	Fama and French (1997)[D]	Utilities					
		0.31	Fama and French (1993)[D]	Broad market					
		0.26	Fama and French (1995)[D]	Broad market (Small)					
		0.25	Fama and French (1995)[D]	Broad market (Big)					
		0.21	Fama and French (1997)[D]	Energy					
Momentum	**Four-Factor**	0.07	Carhart (1997)	Broad markets					

[A] Country-, Industry-, Operation, or Time-specific.

[B] Evidence of non-linearity or asymmetric shock.

[C] Mean coefficient.

[D] For the three- and four-factor models, this table reports the middle percentile portfolio across size, value and/or momentum premium.

[E] Dependent variable is ‘cost of capital’ rather than stock returns, therefore carbon negatively impacts firms by making equity costly.

3.2 Asset Pricing Models

This section begins by outlining the theoretical foundations for the Modern Portfolio Theory (Markowitz, 1952) and the CAPM (Sharpe, 1964, Lintner, 1965) in Section 3.2.1. The theory is the foundation of asset pricing models in both energy economics and finance literature. Section 3.2.2 reviews empirical analyses from the finance literature, introducing stock market risk factors which produce the three- and four-factor models of Fama and French (1993) and Carhart (1997). Section 3.2.3 reviews empirical analyses from the energy economics literature, which concurrently extends the CAPM parallel to the finance literature, augmenting the CAPM with term structure and commodity risk factors. Section 3.2 is concluded by proposing the AFFM – a combination of both energy economics and finance literature.

3.2.1 The Mean-Variance and Capital Asset Pricing Models

The literature review begins with Markowitz (1952), who considers two prior rules of investment which were argued to explain investment behaviour: 1) investors maximise discounted expected, or anticipated, returns; and 2) investors consider expected return to be desirable, while variance of return is considered undesirable. The rules suggest that investors would show preference for maximising return and minimising risk (measured as variance of return). The rule suggests that investors would place all their funds in the security with the greatest discounted value, ignoring the possibility that a diversified portfolio could be preferable to a non-diversified portfolio (Markowitz, 1952).

While the average return across securities can be calculated as the weighted sum of expected values, the weighted variance must be calculated differently, as the variance of securities within the same industry can be interrelated, exhibiting ‘covariance’, compared with firms across various industries (Markowitz, 1952). Accordingly, the investor has a choice of numerous combinations of expected returns (E) and expected variance (V) which is determined by their choice of securities and relative weighting invested in each. The investor will have a preference for all efficient combinations of E-V which produce minimum V for a given E, or maximum E for a given V, known as the mean-variance (E-V) principle (Markowitz, 1952, Lintner, 1965). The relationship between risk and return from Markowitz’s (1952) paper is the basis of Modern Portfolio Theory, the systematic risk literature and much of the asset pricing literature to date.

Building on Markowitz' work, Sharpe (1964) and Lintner (1965) extend and develop a theoretical asset pricing model under the conditions of risk that includes *market* equilibrium,[34] the CAPM. The CAPM begins with a similar argument that a rational investor has a preference for expected returns and a preference against variance of returns, *ceteris paribus* (Sharpe, 1964, Lintner, 1965). In equilibrium, a rational investor with a diversified portfolio is able to obtain higher expected rates of return by incurring additional risk along the *capital market line*. This occurs as the capital market presents two prices to an investor: the *price of time*, pure interest rate with minimum level of risk, and the *price of risk*, the additional expected return per unit of risk borne.

Sharpe (1964) argues that a relatively simple formula can relate the expected return on an individual asset, i, to a combination of assets, m. The combination of assets, m, represents the market portfolio, expected to be mean-variance-efficient. In reality, asset i will show a dispersion of observations around its mean – the approximate expected value of i. This dispersion, or variance, is evidence of the asset's total risk, similar to Markowitz's (1952) measure of risk. However, part of the dispersion is related to the underlying relationship between asset i and combination m. This common component is termed systematic risk, while the remainder, the dispersion around the expected value, is the unsystematic component. Sharpe (1964) argues that the systematic risk component can be estimated using a linear regression. Specifically, the CAPM predicts that the expected excess return to asset i is linearly related to the risk of the asset in the portfolio of all marketable assets (the market portfolio):

$$E(\tilde{R}_i) - R_f = a + \beta_i[E(\tilde{R}_m) - R_f], \tag{3.1}$$

where R_f is the return on the risk-free asset (such as a treasury bill), a is the intercept, $E(\tilde{R}_m)$ is the expected return on the value-weighted market portfolio and β_i is the $cov(\tilde{R}_i, \tilde{R}_m)/\sigma^2(\tilde{R}_m)$ which is interpreted as the risk of asset i relative to the risk of the market portfolio. The covariance of $\tilde{R}_i$ with $\tilde{R}_m$, $cov(\tilde{R}_i, \tilde{R}_m)$, measures the contribution of asset i to the variance of the return to the market portfolio, $\sigma^2(\tilde{R}_m)$ (Schwert, 1981). If portfolio risk is measured by the variance of the rate of return, β_i is a standardised measure of marginal risk. Therefore, only the differences among the equilibrium expected returns to assets are attributable to differences in systematic risk (Schwert, 1981). If the systematic component

---

[34] Note; it is widely acknowledged in finance literature that Jack L. Treynor also produced unpublished manuscripts in 1961 and 1962 regarding market value, time and risk. The implications are similar to Sharpe (1964).

explains average returns, the intercept of the CAPM should be indistinguisible from zero (Fama and French, 1998).

Naturally, assets which are more sensitive to market movements have a higher market beta and higher expected returns, whereas assets with lower sensitivity are defensive and have lower returns. Given the ability to diversify across multiple assets, and avoid the unsystematic component of risk, rational investors are only expected to be compensated for the systematic component of total risk. The CAPM theory does not make predictions regarding the parameter values, but only about the form (linear) of the cross-sectional relationship. Thus, widely-used portfolio grouping procedures can still support the CAPM theory even when it is false; a random grouping of stocks can cancel out individual asset deviations, thus can still produce a spurious return/beta linearity relation (Roll, 1977). While Sharpe's (1964) CAPM is theoretical, real-world data show that this underlying relationship exists. For instance, using data from Section 4.2.3 of this thesis, Figure 3.1 shows a linear relationship between excess returns in the European energy utility sector and a market portfolio of assets. Yet, the deviation between the expected return and the observed return suggests that the CAPM cannot explain all variance of returns. As shown in Table 3.1, the impact of the market on returns is often the greatest and consistently positive for oil & gas and energy utility firms, with papers finding statistically significant and positive coefficients which typically ranged from 0.99 to 0.11, skewed towards the larger coefficients. No paper found a negative impact or no impact from broad market returns. The relationship with broad market returns, even in the context of identifying additional risk premia, is routinely found to affect returns across all sectors. The expectation for this thesis is that the European energy utility sector will have a significant, positive estimated coefficient with the market factor, but will rank among the most defensive sector investments with a beta less than unity.

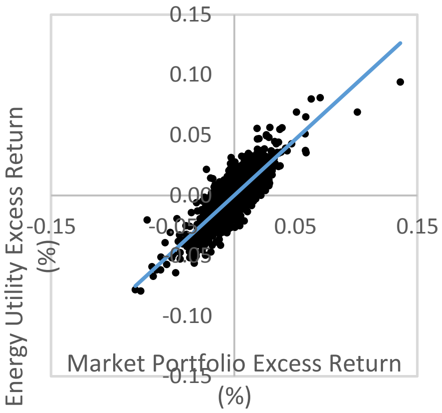


FIGURE 3.1: THE RELATIONSHIP BETWEEN ENERGY UTILITIES AND A MARKET PORTFOLIO

Using daily data from Section 4.2.3, this figure illustrates a simple two-way scatter between excess returns on the European energy utility sector and excess returns on the market portfolio, between 01 July 1996 and 30 June 2013. A linear trendline is fitted.

Having established the theoretical foundations, the literature relevant to this thesis begins to diverge into two streams: the *energy economics* and the *finance* literatures. The purpose of this chapter is to show that there can be a reintegration between the two, and that a synergistic combination of the propositions from both streams of the literature can create an asset pricing model which is superior at explaining returns in the energy sector compared with either body of literature in isolation.

First, Section 3.2.2 reviews the finance literature, which argues that the CAPM has insufficient power to capture all systematic risk elements and that additional stock market risk factors help explain a greater cross-section of return. Second, Section 3.2.2, addresses the energy economics literature, which augments the CAPM to include commodity risk factors which are argued to explain a greater cross-section of returns in energy stocks or commodity-related industries. The augmented CAPM is the basis of the asset pricing models utilised by Oberndorfer (2009a) and Koch and Bassen (2013) to examine returns for European energy utilities. The lack of stock market risk factors in the energy economics literature implies that the latter two papers also suffer from the CAPM's deficiencies. One contribution of this thesis is the inclusion of the stock market risk factors in asset pricing for European energy utilities.

3.2.2 Fama & French's and Carhart's Factor Models

The finance literature extends the CAPM to develop an asset pricing models which can explain a greater proportion of shared stock market variation. The need for such asset pricing models arises from evidence that the cross-section of average returns in U.S. stocks shows little relation with market beta (β), a key proposition of Sharpe (1964) and Lintner (1965). As markets are assumed to be efficient, there should be few factors which can explain returns beyond the systematic market factor. Some academics question assumptions of market efficiency based on evidence of patterns in average returns which are not explained by the CAPM. These patterns in average returns – called market anomalies – may represent evidence of market inefficiency.

Throughout the finance literature, a common criticism of the results is the apparent lack of theoretical justification for the seemingly arbitrary indicator variables found to affect stock returns (Fama and French, 1995). Regardless of whether the variables themselves represent economic relationships, or proxy for latent variables, they are consistently found to explain a significant proportion of stock returns. The finance literature has since attempted to begin filling this economic void by examining whether there is a rational explanation for the incorporation of these additional risk factors into asset pricing models, and whether they proxy for a latent variable. The following sections outline the most influential asset pricing models in finance to date, the three- and four-factor models.

An early paper regarding market inefficiency is De Bondt and Thaler (1985). De Bondt and Thaler (1985) argue that research in psychology suggests that individuals overreact to information, especially unexpected and dramatic news events. This argument was critically received by financial economists, who regard anomalies as statistical artefacts or misspecification of the CAPM. De Bondt and Thaler (1985) test a simple proposition: if prices systematically overshoot fundamentals, then their reversal and price corrections in the opposite direction should be predictable from past return data alone. Their results show clear evidence of an asymmetric reversal effect, with loser portfolios outperforming the market by an average of 19.6%, and winner portfolios earning 5% less than the market. Further, the average market betas of the winner portfolios were larger than the loser portfolios, suggesting that the loser portfolios are less risky. De Bondt and Thaler (1985) show consistencies with overreaction and violation of weak form efficiency. Importantly, their results suggest that these risk factors were not statistical artefacts or misspecification and may have a key role in explaining average equity returns. The finance literature began exploring the existence of such factors.

The following sections, Sections 3.2.2.1 and 3.2.2.2, represent important milestones in the finance literature, examining the impact of firm size and book-to-market ratio to explain average stock returns. The most important finance papers with regard to this thesis are Fama and French (1993) and Carhart (1997), producing the three- and four-factor asset pricing models (see Sections 3.2.2.3 and 3.2.2.4, respectively).

3.2.2.1 Size risk factor

Banz (1981) continues the CAPM literature by examining the existence of a firm 'size effect' in stock returns, measured as the relationship between a firm's total market value of common equity stock and equity returns. The results show that the common stocks of small firms have, on average, higher risk-adjusted returns of approximately 0.4% per month compared with large firms. The significant effect was found to persist between 1936 and 1975 with varying stability, suggesting that the traditional CAPM is misspecified. Chan et al. (1985) build on Banz (1981) to provide evidence as to why firm size represents a significant risk factor in returns using a multi-factor asset pricing model. Chan et al. (1985) also find evidence of the CAPM's misspecification. Chan et al. (1985) create 20 portfolios based on firm size and implement cross-sectional regressions on a month-by-month basis. Results show that the returns of smaller firms exceed larger firms by a difference of 0.956% per month, approximately 11.5% annually. Chan et al. (1985) find that small firms are more exposed to production risk and changes in risk premia. Further analysis shows that the market component has a greater impact on returns than other variables. Chan et al. (1985) conclude that smaller firms are riskier than larger firms due to greater fluctuation with economic expansion and contractions. Further, Kumar (2009) argues that small firms are typically more difficult to value, or may be informationally sparse which biases value. Overall, the higher average returns of smaller firms are justified by the additional risk exposure in efficient markets.

Chan and Chen (1991) extend the literature on firm size to further understand why small capitalisation stocks earn higher mean returns than large-capitalisation stocks. The size of the firm does not necessarily imply higher risk and the difference in market capitalisation does not explain why firms of various sizes have different responses to economic news. Chan and Chen (1991) suggest that the small firm portfolios are more likely to contain ‘marginal firms’ which have lost market value due to poor performance, are inefficient and are likely to have high leverage and cash flow problems. The expectation is that these marginal firms in a competitive economy, with ongoing technological changes, will decrease in relative size and therefore fall from larger size-based portfolios into smaller portfolios. Chan and Chen’s (1991) analysis included the typical approach of sorting the firms into portfolios based on size. Importantly, the descriptive results of Chan and Chen (1991) showed that 66% of the bottom quintile was comprised of firms that had fallen from higher quintiles over the past 10 years, compared with only 14% being directly listed in the bottom quintile. The interpretation is that the bottom quintile captures firms which have not been performing well over recent periods. Moreover, of firms that are forced to cut dividends, suggesting poor performance or an uncertain future, over 50% were also allocated in the bottom quintile. Also, firms in the bottom quintile have greater leverage. The results of Chan and Chen (1991) were clear: smaller firms have higher average monthly returns, higher leverage betas and higher dividend betas compared with larger firms. After capturing leverage and size effects, the market betas of the portfolios were indistinguishable from unity, evidence that market beta affects all firms but the differential responses of small and large firms can be captured by additional risk factors.

3.2.2.2 Book-to-market risk factor

Independent to the size-effect literature, Rosenberg et al. (1985) question market efficiency from a practical perspective. Rosenberg et al. (1985) report statistically significant abnormal performance of straightforward investment strategies. One strategy, originally known as ‘book/price’, focuses on purchasing stocks with a high ratio of book value of common equity (per share) to market price (per share) and selling stocks with low book/price ratios. The justification for examining the book/price ratio is based on prior evidence of significance when testing the earnings/price ratio. However, extensive quantitative research on desirable anomalies, such as the earnings/price ratio, may now result in the ratios' incorporation into asset prices, reducing the usefulness of the prior market anomaly (Rosenberg et al., 1985). The lack of prior research on book/price ratio suggests that the ratio may serve as an unspoiled instrument. The results show strong and significant performance for the book/price strategy, generating an average abnormal return of 36 basis points per month. After trading costs, the book/price ratio would remain profitable as portfolio turnover is expected to be less than 5% per month. Rosenberg et al. (1985) conclude, specific to their universe of companies and time period, that the success of the ratio suggests actual market prices were inefficient and potential profits could be made. The book/price ratio identified in Rosenberg et al. (1985) was the precursor to the modern book-to-market ratio, which became widely accepted and tested, as it was a simple method of demonstrating market inefficiency in the U.S. stock market.

Chan et al. (1991) extend the research on the book-to-market ratio, exploring the cross-sectional predictability of equity returns in the Japanese and U.S. equity markets. The variables tested include earning yields, cash flow yield, firm size (measured as market capitalisation of equity) and book-to-market ratio. The results showed that the book-to-market ratio and cash flow yield had a reliable and positive impact on expected returns, while the impact of size was highly dependent on the model specification and time period. Across all variables, the book-to-market ratio was the most economically significant.

The following sections outline the three- and four-factor models, which are implemented in the portfolio construction and analysis sections of this thesis (see Sections 4.2.4 and 5.3.3).

3.2.2.3 The three-factor model

Fama and French (1992) also build on previous literature to evaluate the role of various fundamentals on the cross-section of average returns on NYSE, AMEX and NASDAQ stocks between 1963 and 1990. Variables included market beta, firm size, earnings/price ratio, market value of equity, leverage ratios and book-to-market ratios. Fama and French (1992) find a lack of support for the central prediction of the CAPM, namely, that the average stock returns are positively related to market beta. Instead, results show that stock risks are multidimensional, with size and book-to-market ratios representing additional dimensions of risk which explain cross-sectional stock returns.

Fama and French (1993) extend Fama and French (1992) by expanding the set of asset returns to be explained, expanding the set of variables used to explain asset returns and adopting a different approach to testing asset pricing. The method implemented uses a time-series approach on stocks and bonds regressed against a market portfolio of stocks and mimicking portfolios for size, book-to-market equity (BE/ME) and term structure risk factors – with the latter expected to affect bond portfolios. As this thesis follows the research method extensively, a detailed explanation, the justification and rationale for this approach is provided in Section 4.2.4.

Fama and French (1993) construct a 5×5 matrix of firms, grouped into portfolios based on 5 quintiles of firm size and 5 quintiles of BE/ME values. These 25 portfolios are used as dependent variables of the regression models. Each of the dependent variable portfolios are regressed against a proxy for the market factor,[35] a size premium and a value premium. The size premium captures the return spread between small and big stocks, while the value premium captures the return spread between high-BE/ME and low-BE/ME stocks. Fama and French (1993) find that both the CAPM and the three-factor model are able to explain excess returns in equity stocks. This is due to both models containing the market factor, which is a value-weighted combination of returns on all stocks. The CAPM is proficient at explaining returns for big stocks as their market capitalisation dominates total market value. However, the CAPM produced various betas and regression fits for the small and high-BE/ME portfolios. Within the paper, Fama and French (1993) also hypothesise that if there are multiple common factors in stock returns, then they are buried within the market factor and need to be drawn out. The results showed that including the size and value premia increased explanatory power for the small and high-BE/ME stocks, and the market betas of all 25 portfolios tested collapsed towards unity – implying that the market factor previously absorbed size and value premia. To test this proposition, they independently regress the market factor against the size and value premia, along with bond market factors. Results show that the size and value premia capture some variation in the return of the market factor, producing an R^2 of 0.38, confirming that size and value premia are priced into the market factor and must be drawn out independently.

The main results of Fama and French (1993) are clear: the CAPM cannot explain a cross-section of returns, as the market factor is weighted towards big firms. When using a time-series regression, the size and value premia capture strong common variation in equity

---

[35] Note that this is not a pre-existing market index; Section 4.2.3 addresses this method of construction and its implication on the results.

returns which are ordinarily obscured within the market factor. However, size and value premia in isolation are insufficient at explaining returns and must be modelled in conjunction with the market factor. The estimated coefficients for size and value premia can be used to calculate the spread in expected returns for firms of different size or book-to-market ratio. The predicted spread in average returns based on size shows that small firms outperform big firms by 0.46% per month, while the predicted spread based on book-to-market ratio shows that high-BE/ME stocks outperform low-BE/ME stocks by approximately 0.40% per month. Including all three risk factors also produces insignificant intercepts in the majority of cases, indicating that the risk factors absorb common time-series variations in returns and are good at explaining the cross-section of average returns.

Further, Fama and French (1993) test whether bond market risk factors help explain average stock returns. The inclusion of both term premium and default risk have a positive impact on equity returns with estimated coefficients of 0.8, but the expected term premium varies through time with business conditions. The energy economics literature in Table 3.1 and Section 3.2.3 also find varying impacts from term premium, with positive (El-Sharif et al., 2005, Ramos and Veiga, 2011), negative (Sadorsky, 2001, Boyer and Filion, 2007) or no impact on equity returns (Oberndorfer, 2009a). As the average return on term premium is small, Fama and French (1993) show that term premium is often significant in isolation but it explains very little of average stock returns when competing against stock market risk factors; the estimated coefficients often become insignificant. Fama and French (1993) conclude that the three stock market risk factors (market factor, size and value premia) are suitable for explaining average equity returns. The most striking feature of the paper is that a simple sorting of firms into portfolio based on similarity of characteristics can explain a large proportion of common returns. Naturally, the lack of economic rationale for the Fama and French (1993) three-factor model has led to a wealth of scepticism, which Fama and French have attempted to address in subsequent papers.

Fama and French (1995) examine whether size and book-to-market proxy for behaviour of firm earnings. Their results show that firms with persistently low earnings on assets, at least five years before and five years after portfolio formation, tended to have high-BE/ME ratios and positive HML slopes. In contrast, strong firms with persistently high earnings tended to have low-BE/ME and negative HML slopes. These results are similar to Chan and Chen (1991), where firm distress is not captured by market return and is compensated in average returns. Controlling for BE/ME ratio, firm size is also related to profitability of firms, with small firms tending to have lower earnings on assets than big firms. Interestingly, Fama and French (1995) find that small firms did not participate in the boom in the middle to late 1980s, but instead suffered a prolonged earnings depression, suggesting that the size premium may vary across time.

Fama and French (1996) also attempt to address criticisms that portfolios formed on other factors, such as earnings/price, cash flow/price, sales growth and long-term past returns, may uncover additional dimensions of risk. Results show that the three-factor model explains strong patterns in returns for portfolios formed on earnings/price ratios, cash flow/price ratios and sales growth. Fama and French (1996) argue that many of the average-return anomalies are related, and therefore can be captured by the three-factor model.

Fama and French (1997) also examine estimated cost of capital at the industry-level using the CAPM and the three-factor model, providing a method of implementing the CAPM and three-factor model at industry-level.[36] Their results make two contributions. First, Fama and French (1997) find that local versions of the three-factor model typically have greater explanatory power than global models. Further, they implement rolling regressions which show that true slopes of the risk factors change through time. This has importance in the context of this thesis, as it may help explain evolving returns through time as a result of inter-temporal risk factors or the effect of regulatory changes. The stability of the relationship between returns and risk factors is empirically addressed in the inter-temporal analysis, Sections 4.3.2.2, 5.4.2.2 and 5.4.2.3 of the thesis.

Finally, Fama and French (1998) also examine international evidence for the existence of the value premium in the U.S. and 12 additional countries from Europe, Australia and the Far East. Fama and French (1998) find that value firms (high-BE/ME) typically outperform growth firms (low-BE/ME) by 7.68% per annum on global portfolios. Since the value premium can be found out-of-sample, relative to U.S. tests, the results lend credibility to the argument that the additional return premium for value stocks is real (Fama and French, 1998).

3.2.2.4 The four-factor model

Simultaneous to the three-factor model, academics began to examine the impact of persistence of earnings and its role in asset returns. Jegadeesh and Titman (1993) examine the efficiency of the stock market and profitability of various trading strategies. Similar to De Bondt and Thaler (1985), they assume that such strategies can only be profitable if stock prices over- or under-react to information. The theory is extended by suggesting that there can be persistence to returns, in which past winners (losers) achieve positive (negative) returns in the future. Jegadeesh and Titman (1993) form a variety of portfolios based on past returns and

---

[36] This method is utilised in Chapter 5 of this thesis, Section 5.3.3.

hold the assets for various time horizons. The results show that buying past winners and selling past losers realises significant abnormal returns of 12.01% per year, between 1965 and 1989. The evidence suggests that this profitability is not due to systematic elements nor lead-lag effects from delayed stock price reactions, but rather is due to the relative strengths of winners and losers.

Carhart (1997) examines the impact of persistence of earnings in mutual fund performance. Carhart (1997) incorporates Jegadeesh and Titman's (1993) momentum variable into Fama and French's (1993) three-factor model, producing the four-factor model specification. Momentum premium[37] is calculated as the difference between the returns on upper and down momentum stocks. Importantly, Carhart (1997) controls for survivorship bias,[38] as about one-third of the sample cease operations. Results show that buying winners and selling losers yields a return of 8% per annum. Moskowitz and Grinblatt (1999) also provide empirical evidence examining the impact of momentum on abnormal returns, finding that momentum can contribute up to 12% per annum over an intermediate horizon, dissipating between 12 and 24 months. Both of these results echo Jegadeesh and Titman (1993). The importance of these papers is that the momentum strategy can be incorporated into the three-factor model, producing a superior four-factor model of market equilibrium.

In a more recent paper, Fama and French (2012) incorporate Carhart's (1997) momentum risk factor to examine local versions of the four-factor model, where the mimicking portfolios are formed on a regional basis across 23 countries in North America, Europe, Japan and Asia Pacific. The motivation is that when securities are from the same region, the asset pricing regressions should typically have greater power, as the regression fits are tight, resulting in higher R^2 values. Most regions, except Japan, exhibited strong momentum effects which result in difficulty capturing average returns. This finding may be present in the European energy utility sector, where regulatory changes are expected to persistently benefit or hinder firm performance. By including a momentum risk factor, the asset pricing model controls for possible momentum effects. Fama and French's (2012) results show that value premium (HML) was larger for small stocks and the momentum spread (UMD) decreases from smaller to big stocks. Furthermore, the results show that local models have greater power than global models – therefore, ideally stock market risk factors

---

[37] Note, momentum premium can also be denoted 'winners minus losers (WML)'.

[38] Both Oberndorfer (2009a) and Koch and Bassen (2013) fail to control for survivorship bias in their empirical analysis of the European energy utility sector; see Section 1.5.4. As outlined in the thesis' contributions, Section 1.5, the method of sample selection utilised in this thesis controls for survivorship bias, as it is expected to exist in the European energy utility sector and may affect stock market risk factors such as momentum (see Section 4.2.2).

should be calculated on a local basis. This thesis extends this proposition in Chapter 5, calculating stock market risk factors on a sectoral basis, as the characteristics of the energy sector are likely to be different to other European sectors.

3.2.2.5 Concluding reflections on the finance literature

To summarise, the market factor of the CAPM is insufficient to explain stock returns across a diverse set of stocks. The finance literature provides clear evidence that additional stock market risk factors, such as size, value (book-to-market) and momentum premia, help explain average returns across industries and countries. The need to incorporate these risk factors into the energy economics literature has been identified. As stated in Section 1.5.1, the reliance on outdated asset pricing models was highlighted by El-Sharif et al. (2005), while the desire to incorporate standard finance risk factors was suggested by Oberndorfer (2009a). However, these factors have still not been incorporated into European energy utility asset pricing models to date. Elyasiani et al. (2011) has taken steps to address this issue for the U.S. oil & gas industry, incorporating Fama and French’s (1993) size and value premia but has failed to address Carhart’s (1997) momentum premium. However, this again fails to acknowledge that the energy utility sector has distinct differences to the oil & gas sector. The latest contribution for European energy utilities, namely Koch and Bassen (2013), failed to address this research niche. This thesis addresses this gap by producing an asset pricing model which reintegrates the two bodies of literature leading to the AFFM. The following section outlines the development of the augmented-CAPM which is typically implemented in the energy economics literature.

3.2.3 Augmented-CAPM from Energy Economics

In a closely related field to the finance literature, the energy economics literature also developed various asset pricing models from the existing CAPM. As noted in Section 3.2.2, the finance literature is primarily concerned with searching for market anomalies which explain average returns across a diverse range of stocks. In contrast, the energy economics literature has focused on identifying macroeconomic variables which were argued to be systematically priced into stocks (Chen et al., 1986). While the two bodies of literature evolved simultaneously, they had already diverged into two distinct fields prior to establishing the three-factor model of Fama and French (1993). Combined with the macroeconomic focus, this may explain why the two bodies of literature are rarely reintegrated and the stock market risk factors are largely ignored in the energy economics literature.

Common extensions of the CAPM implemented in the energy economics literature include term premium and commodities as risk factors which are thought to affect stock returns. Most energy economics research which examines the relationships between financial markets and commodities, primarily oil prices, can typically be separated into three themes: the impact of commodity risk exposure on 1) broad market returns (Chen et al., 1986, Jones and Kaul, 1996, Park and Ratti, 2008, Cunado and Perez de Gracia, 2014, Narayan and Gupta, 2015), 2) multiple sectors and industries (Huang et al., 1996, Faff and Brailsford, 1999, Nandha and Faff, 2008, Arouri, 2011), or 3) the oil & gas sector (Manning, 1991, Sadorsky, 2001, El-Sharif et al., 2005, Ramos and Veiga, 2011, Elyasiani et al., 2011).

With respect to the last two categories of studies, it is evident that the majority of the literature includes energy utilities as a subset of the oil & gas sector. Alternatively, the energy utility sector is argued to be non-competitive and to have natural monopolies (see Megginson et al., 1994; Newbery and Pollitt, 1997), which must undoubtedly bias financial return and valuation pre-liberalisation. Thus, very few papers consider energy utilities as a separate sector when estimating commodity risk exposure. The literature has tended to assume that the results for the oil & gas sector hold for energy utilities. This assumption is held for various reasons. First, the two sectors are associated with the same commodities (crude oil and natural gas). Second, the input and outputs of the sectors are homogenous and traded on international exchanges (Oberndorfer, 2009a). Third, both sectors have high capital intensity, involving large sunk costs and long-term investments (Sadorsky, 2001). Given the limited number of prior contributions on the asset pricing of European energy utilities in isolation (Oberndorfer, 2009a, Koch and Bassen, 2013), this literature review juxtaposes these studies with similar studies on the asset pricing of the oil & gas sector, where there has been considerably more work. Notwithstanding this, a conclusion of this chapter is that the sectors should be analysed independently. As noted, a summary of empirical results and estimated coefficients from the energy economics literature is also provided in Table 3.1.

In reviewing the literature on asset pricing of the oil & gas and energy utility sectors, it is important to note from the outset that the impact of commodity risk exposure will be affected by regulations, market power, the ability to pass on commodity price sensitivities to customers and effective hedging strategies. For instance, Nwaeze (2000) argues that deregulation of utilities exposes them to greater systematic risk and commodity risk. Oberndorfer (2009a) also argues that energy utilities are expected to exhibit non-negligible market power, while electricity consumption is considered relatively inelastic; therefore, it is unclear whether changes in energy prices could be immediately and fully passed on to consumers. As the energy sector has been subjected to multiple liberalisation legislative efforts since 1996 (see Section 2.2.1), the impact of deregulation and the ability to pass on costs to end consumers may not be stable across time. Further, Security of Supply legislation discussed in Section 2.2.4 may also alter the long-term relationship between oil price risk and average sector returns.

Further, effective hedging strategies and, if present, the ability to pass on costs to end consumers will bias results against significance (Faff and Brailsford, 1999). Similar to the oil & gas sector, European energy utilities are large consumers of fossil fuels, including natural gas, coal and, to a lesser extent, oil. In particular, natural gas utilities, like many other petroleum product companies, are price takers of commodities (El-Sharif et al., 2005). The same may be true for European energy utilities, which may hedge to satisfy endogenous acceptable levels of risk taking. If hedging is widespread in the energy sector, then the literature would suggest that results will be biased against significance or the impact will be small. Hedging (and speculation) will be discussed in Section 3.3.5.2. Regardless of hedging strategies, the ability to detect oil or commodity price risk suggests that firms have not realised the full benefits of energy risk management and production hedging.

3.2.3.1 Risk factors in broad market returns

Using multivariate Vector Autoregression (VAR), Generalized Autoregressive Conditional Heteroskedasticity models (GARCH) and linear regressions, researchers have attempted to examine whether an oil risk premium exists in broad market returns. The rationale is that changing oil and gas prices should be incorporated into firm valuation (Oberndorfer, 2009a). If commodities are used as inputs to operations, an increase (decrease) in commodity prices will cause expected earnings to decline (increase), therefore decreasing (increasing) stock prices if the market efficiently capitalises the cash flow implications of the commodity price change (Faff and Brailsford, 1999). Similarly, if industries' output is benchmarked against commodity prices, or energy generators and gas producers are holding large quantities of fuels benchmarked against oil, then market efficiency would suggest that an increase (decrease) in the commodity price will increase (decrease) firm valuation as each market quickly reacts to information shocks in the other markets (Huang et al., 1996). Such propositions are the basis of the oil price risk literature.

Jones and Kaul (1996) examine the relationship of oil risk premium on stock returns in the U.S., Canada, Japan and the UK using quarterly data between 1947 and 1991. Results show that 1) oil shocks have a detrimental impact on the real stock returns, 2) the reaction of U.S. and Canadian stock is rational and can be completely accounted for by oil's impact on real cash flows and 3) Japan and the UK overreact to oil price shocks. Sadorsky (1999) also finds that oil price changes and volatility have a significantly negative impact on real stock returns, with asymmetry between positive and negative shocks. Further, Park and Ratti (2008) find that oil has a significantly negative impact on stock returns of the U.S. and 10 European countries. The impact occurs instantaneously in the same month or within one month, with the results being robust to varying VAR specifications. Cunado and Perez de Gracia (2014) also find that oil price changes have a significant and negative impact on stock market returns for most European countries. Narayan and Gupta (2015) find that both positive and negative oil price changes impact U.S. stock returns, with the negative changes being relatively more important. Further, Narayan and Gupta (2015) show that a long-run relationship between U.S. stock returns and oil prices has existed for the past 150 years. The results show support for an impact of oil price rises on broad market returns.

In contrast, other researchers have also found insignificant oil risk premium in broad market returns. Chen et al. (1986) examine to what extent macroeconomic variables systematically affect U.S. stock market returns between 1958 and 1984. Chen et al. (1986) find that oil betas were mostly insignificant when compared with common risk factors, but their inclusion reduces the significance of other variables, suggesting oil has some minor effect on stock returns. Insignificant oil risk premia is also found by Huang et al. (1996), finding no relationship between daily oil futures returns and broad stock returns between 1979 and 1990, including contemporaneous returns. However, the results show that oil price risk does impact petroleum and some oil company returns, suggesting a sector-specific effect. The likely candidate for the lack of consistency across papers is the fact that the empirical analysis was implemented at the market level. In reality, firms are likely to have differential impacts to oil price risk, particularly if the industry uses oil as an input or an output benchmark. A common practice in the finance literature is to perform empirical analysis on portfolios of firms based on similarity of characteristics.

From a finance perspective, Faff and Brailsford (1999) respond by examining the sensitivity of various Australian industry returns to broad market returns and oil price changes, using monthly data between 1983 and 1996. They argue that industries are not homogenous and that different risk factors will impact industry returns uniquely. In particular, they predict negative oil price sensitivities will be greater for industries with a relatively high proportion of their costs devoted to oil-based inputs. The results showed that industries where the outputs are oil, or oil by-products, have positive sensitivities to oil price changes, while fuel-intensive industries show negative sensitivities. In the context of this thesis, Faff and Brailsford (1999) represents an important inter-sectoral analysis of commodity risk exposure, against which many of Chapter 4's results are benchmarked. The heterogeneous impact of oil across industries has also been documented by Elyasiani et al. (2011), who found that oil futures return distributions constitute a systematic risk factor at the industry level in nine out of 13 industries. Interestingly, oil-using industries were more likely to be impacted by changes in the volatility of oil returns than the oil returns themselves.

3.2.3.2 Risk factors for oil-related industries

Concurrent with the oil and market return literature, other researchers have examined the oil sensitivity of oil-related industries in isolation. Manning (1991) investigates the interaction between UK oil company share prices and the spot price of Brent Crude oil using weekly data between 1986 and 1988. Using cointegration and error-correction models, Manning (1991) found that UK oil-industry returns have positive sensitivities to unanticipated oil price shocks, with the sensitivity being higher for exploration companies and lower for integrated firms. Results are similar to those found by Elyasiani et al. (2011). These findings suggest that oil risk exposure, and more generally commodity risk exposure, not only differs across industries but also within industries (based on operational differences). Moreover, Jamasb and Pollitt (2005) also find evidence that vertical integration may protect utilities from unexpected fluctuations in commodity, wholesale and end-user prices, discussed shortly in Section 3.3.2. Such a finding is important to European energy utilities as regulatory reforms published in 2003 sought to unbundle vertically integrated firms to counteract market dominance (see Section 2.2.1).

Sadorsky's (2001) paper forms the basis of much of the energy economics literature relating to the oil & gas and the utility sectors to date. Sadorsky (2001) examines several risk premia in the stock returns of Canadian oil & gas companies, including: crude oil prices, broad market returns, exchange rate and short-term interest rate (term) premia (see Table 3.1). Exchange rate was included to account for changes in Canada's currency against global oil prices, while term premium was included to control for borrowing costs. Sadorsky's (2001) results show that market returns, oil prices and exchange- and interest-rates all have large and significant impacts on stock returns for the Canadian oil & gas sector. Sadorsky (2001) finds a positive impact for the market factor and oil returns, and a negative impact for exchange rate and term premium. The Canadian oil & gas sector also has a beta less than unity, being less risky than the market and moved pro-cyclically.

Term premium has grown in popularity in the energy economics asset pricing models as a risk factor expected to affect stock returns. Term premium is calculated as the spread between the yields of a three- and one-month treasury bill. Term premium represents the risk-free short-term discount rate and an indicator of the present state of the economy, which tends to be lower during economic downturn and higher in times of growth (Sadorsky, 2001). Unanticipated changes in the riskless interest rate are argued to influence the time value of future cash flows, which in turn affects returns and pricing of an asset (Chen et al., 1986). Changes in interest rates also affect the prices charged for credit, a major influence on the level of corporate profit, which affects equity valuation. Moreover, changes in the cost of carrying margin debt influences the desire and ability for investors to speculate, dampening stock returns (Sadorsky, 1999). As noted in Section 3.2.2.3 and Table 3.1, the significance of the term premium is highly variable. The inclusion of term premium was addressed in Fama and French (1993), who found that its significance decreased when competing against stock market risk factors. It is possible that the significant term premium in the energy economics literature will disappear when competing against stock market risk factors.

Continuing the energy economics literature, El-Sharif et al. (2005) extend Sadorsky's (2001) research method, examining the relationship between the price of crude oil and equity values in the UK oil & gas sector. The analysis is performed inter-temporally, in six month intervals, and inter-sectorally across four additional sectors to identify whether risk factors evolve through time and whether they reflect market-wide or sector-specific concerns. El-Sharif et al.'s (2005) results showed that UK oil & gas stock returns are impacted by several risk factors across time, including: crude oil prices, broad market returns, exchange rate and short-term interest rate (term) premia. Their results are similar to Faff and Brailsford (1999) and Sadorsky (2001), with the exception of term premium. El-Sharif et al. (2005) finds that term premium was mostly insignificant and negative, contrasting Sadorsky's (2001) positive relationship. El-Sharif et al.'s (2005) results also indicate that the relationship between oil price and non–oil & gas sectors is weak, similar to Huang et al. (1996). Moreover, the relationship among oil & gas sector returns and risk factors varies over time and across sectors, with the cross-sectional impact being similar to Faff and Brailsford's (1999) results. El-Sharif et al. (2005) argue that these difference suggest a lack of inter-temporal and trans-national generalisability of results.

Boyer and Filion (2007) also build on Sadorsky (2001), by including natural gas prices as an explanatory variable[39] in explaining Canadian oil & gas sector returns between 1995 and 2002. The sample is divided into producer or integrated oil & gas companies using dummy variables. Results show that broad market, oil and gas returns all have a positive impact on oil & gas sector returns, while exchange rate and interest rate have a negative impact. Fundamentally, their results are similar to Sadorsky (2001). Boyer and Filion (2007) also find

---

[39] Boyer and Filion (2007) also control for an additional five fundamental risk factors related to oil & gas firm operations in excess of those specified by other authors, including variation in drilling success, variation in cash flows, variation in proven reserves, variation in production volume and variation in debt. These factors rarely appear in current literature and are specific to analysis for the oil & gas sector.

various sensitivities to risk factors across time, depending on whether the firm was an oil or gas company. This suggests that returns for the energy utilities sector differ from the oil & gas sector, and may also differ across energy utility operations. Boyer and Filion (2007) find the oil price risk to be greater than market risk, which contrasts with previous literature.

Ramos and Veiga (2011) analyse the risk factors of the oil & gas sector in 34 countries, but extend the analysis by including additional factors related to oil production. Results found evidence that oil price is globally incorporated into sector returns, with a stronger impact in developed countries. The results show that oil industry stock returns respond asymmetrically to oil price hikes and declines. Further, while the oil & gas sector showed exposure to broad market returns, local markets have greater explanatory power – consistent with the lack of inter-temporal and trans-national generalisability found by El-Sharif et al. (2005).

3.2.3.3 The returns of European energy utilities

Given that commodity risk premia are shown to vary across countries and sectors, it is surprising that there is relatively little literature which focuses on asset pricing of European energy utilities in isolation. This is especially true since the restructuring of the European energy utility sector represents one of the most extensive cross-border reforms of any energy network globally (Jamasb and Pollitt, 2005) and has received considerable political and media attention (see Section 1.2 and Chapter 2 more generally). The following paragraphs explain the differences between the oil & gas sector and the energy utility sector. The major differences between the sectors may affect stock returns, and therefore demands that they be examined independently.

The primary difference between the oil & gas sector and the energy utility sector is the independent regulatory environments of the two sectors. Further, the energy sector is comprised of both the electricity and natural gas industries, each having unique characteristics. Admittedly, the natural gas industry may behave in a similar manner to the oil & gas industry. Oberndorfer (2009a) argues that many European energy utilities are integrated and, therefore, no ‘pure’ natural gas producer exists. Thus, the oil & gas literature should be relatively applicable to natural gas utilities. However, the electricity industry has many characteristics which make it unique to the natural gas industry. The electricity industry produces a non-storable good which is delivered via transmission networks, requiring instantaneous physical balancing of supply and demand (Jamasb and Pollitt, 2005). Electricity generators will be sensitive to cost and demand shocks and must forecast electricity supply to prevent overproduction. Further, electricity generators are exposed to the rare possibility of negative pricing. Such factors rarely exist in the natural gas industry or the oil & gas sector. Therefore, it is the intention of this thesis to analyse the sectors and industries in isolation, and then to provide a cross-sectoral analysis in later chapters.

As noted previously, the literature regarding the examination of European energy utilities in isolation is limited to two key papers, namely, Oberndorfer (2009a) and Koch and Bassen (2013). Oberndorfer's (2009a) paper constitutes the first analysis on the stock returns of European energy utilities, focusing on the impact of common and commodity risk factors in asset returns. Oberndorfer (2009a) implements an augmented-CAPM similar to that of Sadorsky (2001) and Boyer and Filion (2007). The CAPM is augmented with European measures of oil and gas price changes, but also includes an international measure of coal price changes due to its importance in electricity generation. Their results show that oil price changes have a positive impact on oil & gas firms and a negative impact on electricity firms. Overall, the positive impact outweighs the negative impact. Oil volatility negatively impacts oil & gas stocks. In contrast to the prior literature, gas returns have no impact. Oberndorfer (2009a) provides two explanations for this finding: 1) traditionally, natural gas prices are linked to oil prices through indexation, with only timid decoupling of prices observed in Europe (Siliverstovs et al., 2005); or 2) results are consistent with Haushalter's (2000) findings of gas price hedging, with utilities hedging more strongly against gas price risk than against oil price risk. Further, the results show that coal returns negatively impacted electricity generators. However, the impact was relatively small in comparison with oil price risk, despite oil's infrequent use in electricity production.

On closer inspection of Oberndorfer's (2009a) research method, the unusual result for coal risk may be due to the composite coal index selected. Despite using European measures of oil and gas, Oberndorfer (2009a) opts to calculate an equally weighted portfolio of three global coal prices, designed to proxy for coal prices in a global market: GI Australia Freight, GI Columbia Freight and GI South Africa Freight. Local markets are more likely to have greater explanatory power (Ramos and Veiga, 2011). Second, the coal index shows a clear temporary shift in average price between late-2003 and mid-2005, which must undoubtedly affect estimated coefficients. The suspicion is that this shift is the result of splicing multiple indices together. Regardless, this thesis improves the measure of coal price risk by including a European-specific coal index to better represent the local cost of coal. The coal index will also avoid splicing. See Chapter 4, Section 4.2.3, for a fuller discussion of commodity risk factors used in this thesis. In addition, Oberndorfer (2009a) uses an unrepresentative sample of European energy utilities, which will be discussed shortly.

Koch and Bassen (2013) examine the carbon risk exposure of 20 European electricity utilities. The sample is delineated into portfolios of high- and low-carbon-emitting generators. Although the focus of the paper is carbon risk exposure, Koch and Bassen (2013) include oil, gas, coal and electricity prices as control variables. The results show varying impacts for oil, gas and coal on electricity utilities' returns. Koch and Bassen (2013) argue that there is no clear-cut evidence for the direction of the impacts, as the impact on each utility, or portfolios of utilities, is based on their emissions profile. Their results show both positive and negative impacts for oil and coal price risks. Interestingly, coal appears to have a positive impact on low-emitting utilities, which contradicts theory.[40] Further, gas has no significant impact on any utilities' returns; again, this is possible evidence of effective hedging strategies. Although carbon risk is insignificant for the majority of the energy utility sector, carbon risk exposure was a relevant risk factor for energy utilities with an extremely high-emitting fuel mix, increasing the cost of capital and reducing the value of equity.

An additional variable of recent years is the introduction of a 'carbon price' for business operations to reduce GHG emissions and avoid dangerous climate change. Emission pricing and abatement is expected to be achieved through market mechanisms (economic instruments), such as carbon tax or carbon emission trading (Pezzey and Jotzo, 2012). Despite being a relatively young market, the impact of carbon price risk has been a topic of intense debate over recent years. The EU ETS began in 2005 as a 'cap and trade', market-based mechanism to reduce community-wide GHG emissions. Participants are required to purchase and surrender carbon allowances to cover annual emissions. The literature suggests that the electricity industry is forced to incorporate European Union Allowance (EUA) prices into operation decisions for existing power plants and future investment decisions (Delarue et al., 2008, Yang et al., 2008). Oberndorfer (2009b) finds a positive coefficient of 0.02 between carbon and European electricity firms, while Koch and Bassen (2013) find that carbon risk positively impacts the cost of capital for high-emitting European energy utilities with an estimated coefficient of 0.05, but has no significant impact on the electricity industry as a whole. Specifically, extremely high emitters suffered a loss of equity value of around 4–6%, while low-emitters did not benefit from carbon discounts. Where applicable, this thesis will examine carbon risk exposure on European energy utility returns.

This thesis is most clearly positioned relative to both Oberndorfer (2009a) and Koch and Bassen (2013), extending their research methods in a number of ways. First, the time series used includes the global financial crisis (GFC) between 2007 and 2009 and the

---

[40] Chapters 4 and 5 of this thesis show that coal price risk may proxy for stock market risk factors.

Eurozone crisis (EUC) between 2010 and 2011.[41] The expectation is that the relationship with risk factors, such as the market factor, commodities and term premia, may change as a result of these crises. Second, this thesis dramatically increases the sample of European energy utilities used in the analysis by controlling for survivorship bias, obtaining a large sample of 88 European energy utilities across all operations. In comparison, Koch and Bassen (2013) examines the carbon risk exposure of 20 publicly traded European electric utilities, while Oberndorfer (2009a) examines 22 European energy utilities across the oil & gas and electricity industries. Both papers fail to control for survivorship bias. Further, Oberndorfer (2009a) removes utilities whose operations are based on renewable energy, creating an unrepresentative sample of European utilities. As this thesis examines renewable energy legislation, this thesis opts to include these utilities in the analysis. Moreover, the inclusion of policy impacts from liberalisation and environmental objectives has largely been ignored in the empirical analysis of the European energy utility sector. Using a more comprehensive sample and controlling for economic shocks reduces bias and therefore advances the literature. To this end, Chapter 2 provided a thorough outline of the ordinary legislative procedure (Section 2.1) and compiled the broadest list of 54 regulatory changes to date, across four major restructuring streams (Section 2.2). Further, to examine the impact of regulatory changes, this thesis develops the AFFM to more accurately explain returns in the European energy utility sector. In total, all these differences mean this thesis represents the most comprehensive and thorough examination of the financial return of European energy utilities in the context of dramatic regulatory change.

3.3 Measuring the Impact of Regulatory Changes

While the literature to this point has focused on asset pricing models, the following section outlines the theoretical frameworks and literature regarding the impact of regulatory changes – specifically, the theoretical framework for the impact of regulatory change on stock value (Section 3.3.1), the impact of liberalisation (Section 3.3.2) and environmental policy objectives including market reaction to environmental news (Section 3.3.3), and the time-varying nature of risk premia using inductive structural break methods (Section 3.3.4). The section ends with a discussion of research method issues regarding asset pricing models (Section 3.3.5).

---

[41] The exact time line of the EUC is still in debate at the time of writing this thesis. The EUC has been unfolding since late 2009, with bailout programmes for European Member States expected to continue until March 2016.

3.3.1 *Theoretical Framework for the Impact of Regulatory Changes*

The theoretical framework outlines how regulations impact the price of an asset through changes to cash flow and discount rate; readers familiar with finance literature may skip ahead to Section 3.3.2. As investors are expected to be rational, wealth-optimising individuals, they will revalue energy utilities' stocks today based on perceived changes to future cash flows as a result of regulatory change (Schwert, 1981). Investors will be concerned with any changes that may affect the level or variability of utilities' operating performance, which also affects the investors' required rate of return on investment. Using the discounted cash flow model, Schwert (1981) shows that changes in stock prices can reflect the total impact of regulatory change. If changes to the regulatory and operating environment can affect the cash flow to an investor, there will be an associated change in the market price for the company's stock, shown in Equation (3.2):

$$(P_{it}^{*} - P_{it}) = \sum_{k=1}^{\infty} \frac{(d_{it+k}^{*} - d_{it+k})}{(1 + r_i)^k} \tag{3.2}$$

where P_{it} denotes the stocks' current price, P_{it}^{*} denotes the expected price after regulatory change, d_{it+k} denotes the current cash flow, d_{it+k}^{*} denotes the expected cash flow after regulatory change, r_i denotes the discount rate and k denotes the number of periods following the regulatory change. Equation (3.2) assumes a constant discount rate. However, regulatory changes may also affect the variability of operating performance, which can manifest as increased uncertainty of financial return, thereby altering the discount rate. This is illustrated in Equation (3.3):

$$(P_{it}^{*} - P_{it}) = \sum_{k=1}^{\infty} d_{it+k} \left\{ \frac{1}{(1 + r_i^{*})^k} - \frac{1}{(1 + r_i)^k} \right\} \tag{3.3}$$

where r_i^{*} is the discount rate after the regulatory change. If market risk proxies for discount rate, then an increase in market risk will decrease the price of the asset and investors should be compensated with higher returns (Schwert, 1981, Basher and Sadorsky, 2006, Basher et al., 2012). In reality, the cash flow in Equation (3.2) and the discount rate in Equation (3.3) may both vary. Overall, the total impact of regulatory change can be estimated from the change in stock prices around regulatory events (Schwert, 1981, Beneish, 1991). Energy utilities' stock should suffer a loss (gain) in market value equal to the present value of the expected loss (gain) on operational performance (Nwaeze, 2000).

It is expected that regulatory announcements are more likely to be anticipated than corporate announcements; this is primarily due to the size of the potential wealth transfer from regulatory changes (Binder, 1985). Also, Section 2.1 showed that there are extensive negotiations between interest groups (energy utilities) and the regulators (EU political institutions) before actual voting; therefore, the outcome may be known ahead of publication (Binder, 1985). In an efficient market, any regulatory change that affects the future cash flows of a firm will cause a change in asset prices as soon as the regulatory change is anticipated in the market; however, it is often difficult to determine when the regulatory change is first anticipated (Schwert, 1981). As the beliefs of market participants are not directly observable, such beliefs must be inferred through market reaction and latent variables such as changes in stock prices (Schwert, 1981, Binder, 1985).

3.3.2 Liberalisation and Privatisation Literature

Section 2.2.1 showed that the objectives of liberalisation were to provide incentives for European utilities to improve their capital investment decisions, operating performance and operating efficiency, with the projection that end consumers would benefit from internal efficiency gains (Berger and Humphrey, 1997, Jamasb and Pollitt, 2000). Liberalisation's objectives were expected to be achieved through: 1) privatisation, 2) lowering entry barriers for new utilities, 3) increasing competition and 4) unbundling vertically integrated utilities. This section addresses each target, as the effects are likely to be numerous. Further, the section draws parallels with the liberalisation of other sectors.

Industry privatisation reduces the number of state-owned enterprises, removes government-backed debt guarantees and exposes firms to the real threat of bankruptcy (Megginson et al., 1994). Lowering entry barriers increases the freedom of entry and exit to any industry, resulting in more start-up companies and increased competition from large, international competitors (Beneish, 1991, Gual, 1999). Increased competition also brings additional expenses to operations. Deregulated and saturated markets face new pressures, such as high financial costs of reorganisation, re-training, increasing brand awareness and cutting unit costs to gain greater market share (Beneish, 1991, Gual, 1999, Nwaeze, 2000, Delmas and Tokat, 2005). Unbundling vertically integrated utilities also reduces insurance against fluctuations in commodity, wholesale and end-user price (Jamasb and Pollitt, 2005). Deregulation can also affect the riskiness of the sector. Nwaeze (2000) finds that deregulation of U.S. electric utilities reduced buffering against the profit effects of cost and demand shocks. As generators compete for access to transmission grids, they can no longer pass all additional operational expenses onto consumers, forcing utilities to absorb the financial burden. This is of concern, as Diaz-Rainey et al. (2011) also find that the current shift towards the marketisation of the EU energy system is forcing incumbents, through competitive pressures, to increasingly rely on the cheapest energy sources in spot markets, rather than maintaining the long-term contracts which were common in the past. The effects of unbundling utilities have been observed in England and Wales, where associated collapses in electricity wholesale prices forced some non-integrated utilities into bankruptcy (Jamasb and Pollitt, 2005). The effects of privatisation have also been observed in other sectors.

Beneish (1991) argued that one of the most pressing concerns of deregulation of the U.S. aviation sector was the freedom of entry and exit in the market. The most prominent feature was a reduction in long-term contracts, resulting in highly variable annual revenue; Section 2.2.1 argued that this issue may also be present in the case of energy utilities, especially electricity generators. Kane and Unal (1988) focused on the impact of regulatory and statutory changes on the temporary variability of unsystematic risk (among other factors) for deposit-taking banks. They found that the bulk of risk changes were from changes to market-beta and unsystematic risk, measured as the regression residual variance. Kane and Unal (1988) utilise a regime-switching model to demonstrate that systematic risk decreased slowly over time. However, some periods showed a dramatic increase in market risk, causing all market betas to rise above unity. This was coupled with an increase in unsystematic risk for banks, with increasing numbers of problem and failed banks. Kane and Unal (1988) find that many events in the banking system resulted in negative abnormal returns for deposit taking institutions.

Overall, liberalisation legislation is predicted to induce greater operating revenue volatility through increased competition, reduced protection from cost and demand shocks and a removal of government-backed debt guarantees. To compensate investors for the perceived increased risk borne, they will expect greater returns on utility investments and investors will buy or sell energy positions based on their perceived changes to future cash flows. Accordingly, the thesis expects negative abnormal returns for energy utilities surrounding regulatory events. As noted in Section 2.2, the EU energy utilities sector was not only impacted by EU liberalisation objectives, it has also been affected by a range of environmentally motivated legislative drives.

3.3.3 Environmental Policy Literature

The issue of climate change and the impact of climate change mitigation on firms is one of the most intensely discussed debates of recent decades (Dobes et al., 2014). In general, GHG emissions have risen over the past 150 years, with an acceleration in emissions around 1950 from energy-related sources (Dobes et al., 2014). While global emissions of GHGs rise, developed countries continue to make small reductions in emissions, which represent a seemingly superficial attempt to disrupt the status quo (McKibben, 2012). At present, the

European Union is committed to reducing greenhouse gas emissions by at least 80% by 2050, compared with 1990 levels (Delarue et al., 2011). Targets are expected to be achieved through more energy-efficient appliances and homes and increased use of renewable energies. To reverse the historical trend in GHG emissions, the expectation is that global mitigation will require significant net economics costs (Dobes et al., 2014). As a result, questions have been risen regarding the degree of effort required to mitigate climate change. Particularly as the increased financial burden of meeting environmental regulations means allocating resources away from other goals (Dobes et al., 2014). In the case of energy utilities, this includes starving other important investment projects, such as equipment and plant upgrades (Walley and Whitehead, 1994). The following sections outline the literature concerning the impact of environmental regulations. Section 3.3.3.1 discusses the impact of environmental policies on operating performance, while Section 3.3.3.2 reviews market reaction to environmental policies.

3.3.3.1 Impact on operating performance

In terms of the existing literature on the impact of environmental objectives on utilities, there is a range of evidence. Many managers view environmental management as compliance with environmental regulations, where control over pollution and maximising profits are mutually exclusive; the two cannot co-exist and the former can only be achieved at the expense of the latter (Bragdon and Marlin, 1972, Walley and Whitehead, 1994). However, most of the literature regarding the cost of climate change mitigation focuses only on the cost of transitioning to low-carbon technologies and practices, rather than also considering the co-benefits of mitigation (Dobes et al., 2014). Some adjustments to firm operations can translate into a competitive advantage, can encourage firms to re-engineer their technology and act as a catalyst for innovation, providing new market opportunities and wealth creation (Walley and Whitehead, 1994).

Gollop and Roberts (1983) examine the effect of air pollution standards on the productivity of the U.S. electricity generating utilities between 1973 and 1979, finding a decline in productivity of 0.59 percentage points per year, increased operating costs and decreasing profitability. By way of contrast, Hart and Ahuja (1996) conclude that strict environmental regulation to lower emissions may improve competitiveness by encouraging efficiency and innovation. Delineating the sample, high polluters appear to derive positive benefits from emission reductions, as there are many simple, low-cost improvements which can be made. However, as ‘zero pollution’ approaches further reductions become expensive due to additional technological investments required (Hart and Ahuja, 1996). Bragdon and

Marlin (1972) argue a similar point, namely, that installing pollution control equipment on an emergency basis, after the plant is built, can be up to three times as expensive as it would be if incorporated into the firm at the beginning. In the case of energy utilities, some retrofits may be limited by plant layout, process integration, plant age and design, emission levels required and the cost of control technologies. For example, air pollution control technologies for coal-fired plants range from 5 to 150 €/kWe (IEA, 2006). Thus, retrofits to existing energy utilities may be costly as the EU increasingly ‘greens’ the energy supply. Regarding carbon allowances, Koch and Bassen (2013) find that carbon-intensive, fossil fuel dependent utilities are disproportionately affected by carbon risk from the EU ETS. Accordingly, it is generally perceived that environmental objectives increase the financial burden of operation.

While the preceding literature focuses on the impact of environmental objectives on operating and financial return, the Energy Efficiency and Renewable Energies streams in Sections 2.2.2 and 2.2.3, respectively, also affect the operating environmental of energy utilities. Energy efficiency objectives seek to reduce EU energy demand (see Section 2.2.2). Delarue et al. (2011) review three European reports which focus on the impact of energy efficiency on energy demand. Although high energy-consuming appliances such as ovens, refrigerators and lighting are already included under current legislation, there is the possibility of future technological advances which will further reduce energy consumption and demand. The overall impact is an estimated reduction in energy demand of 10% to 20% (Delarue et al., 2011). However, this estimated reduction must also be balanced against population growth and the expected electrification of sectors, such as transport, which increases future energy demands. These are addressed under the Renewables Energies stream.

The Renewable Energies stream (Section 2.2.3) increases technological and physical risk for energy utilities because 1) it forces utilities to invest in technologies that are still not fully mature; 2) it affords grid priority to renewables, meaning that existing energy generation assets are not used as efficiently as they could be; and 3) it adds uncertainty to revenues and operations as these variable energy sources can only operate in favourable weather conditions and volatile weather impacts wholesale spot prices (Green and Vasilakos, 2010, Ahlstrom et al., 2015, Newbery, 2015, Riesz and Milligan, 2015). Furthermore, policies such as feed-in-tariffs and grid priority for renewables can incentivise some conventional generators to place negative bids into the wholesale electricity market during low residual loads, as turning off generation would incur additional costs and risks (DECC, 2010, Fanone et al., 2013, Ahlstrom et al., 2015, Riesz and Milligan, 2015).

3.3.3.2 Market reaction to environmental policy

As discussed in Section 1.2.2, the concept of socially responsible investing has gained prominence in recent years, with environmental performance identified as a criterion assessing whether a firm is a good investment (Filbeck and Gorman, 2004). More than ever, investors are paying close attention to the actions of managers regarding the social responsibility of a company (Ansar et al., 2013). Specifically, individuals and investors are encouraging firms to adopt corporate practices which seek to maintain an equilibrium between financial return and social good. The market also responds to poor environmental management decisions which would create liabilities, negatively impacting firm value (Filbeck and Gorman, 2004). Certainly, firms are beginning to acknowledge that environmental performance can influence firm valuation, with many international firms now publishing annual environmental performance reports (Klassen and McLaughlin, 1996). However, the future impacts can be difficult to quantify, particularly as many of the climate change impacts are either uncertain or include qualitative, non-market impacts such as losses in ecological function (Dobes et al., 2014). As this thesis approaches the analysis from a financial perspective, it implicitly assumes that all investors are rational and consider all potential future scenarios, including hard to value options (Griffin et al., 2015). The following outlines papers regarding the market reaction to environmental events.

Klassen and McLaughlin (1996) examine the linkages between financial return and environmental management of firms. Klassen and McLaughlin (1996) hypothesise that the strong (weak) environmental performance of a firm will positively (negatively) affect financial return, which may vary across industries. Their results show significant and negative market responses of -0.82% to -1.50% for weak environmental management and environmental crises. In contrast, significant and positive market responses of 0.63% are found for strong environmental management, as indicated by performance award nomination. The impact of positive responses is lower for firms in environmentally unfriendly industries, possibly indicating market scepticism to environmental efforts, which is relevant to the poor environmental history of energy utilities. Further, their results are similar to Karpoff and Lott (1993), who find press reports of allegations or investigations of corporate fraud results in an average stock price decrease of -1.34% ($60 million) against private parties and -5.05% ($40 million) against government agencies. Note that the absolute decrease in value is greater for private firms. This may have implications for the liberalisation of the European energy utility sector, where energy utilities are becoming increasingly exposed to the impact of regulatory changes as the EU shifts towards a privatised energy sector.

For energy-intensive industries, Walley and Whitehead (1994) estimate that anywhere between one-quarter and one-half of an industry's market valuation is vulnerable to increased environmental compliance costs. Filbeck and Gorman (2004) examine the relationship between financial return and environmental compliance for 24 electric utilities, between 1996 and 1999. The paper focuses on positive environmental performance as a criterion of success factor and good investment. The sector was chosen as producers and distributers of energy typically have high emissions. Firms are compared with a benchmark of environmental performance. The results contrast with the previous literature, finding that that less compliant portfolios outperform compliant portfolios. Further, results show no positive relationship between environmental and financial return. There are several conclusions drawn in the paper. First, the compliance index measures how well the company is complying with *existing* regulations – market efficiency would suggest that this information has already been impounded into stock prices. Second, the compliance index does not measure proactive management beyond minimum compliance (Filbeck and Gorman, 2004). Third, the electric utility industry has a dramatically different regulatory environment to other industries. The implication of this latter point is that European energy utilities may now show greater sensitivity to the environmental objectives as the sector has also been liberalised over recent decades (see Section 2.2.1).

Griffin et al. (2015) explore the stock market's reaction to a *Nature* article which acknowledges that only one-quarter of the world's fossil fuel reserves can be used if society is to avoid dangerous climate change. The implication of the article was that much of the world's fossil fuel reserve would become stranded and unburnable, making the assets worthless as a result of climate change response. These probable and proven reserve contribute a significant portion of firm valuation (Harris and Ohlson, 1987, Quirin et al., 2000). In particular, 40% to 60% of the market capitalisation of the top 200 global energy companies is potentially value at risk as energy firms' share price partially depends on their reserves (Spedding et al., 2013, The Economist, 2013a). Griffin et al. (2015) found that the publication of the 2009 article produced an average stock price decline between -1.52% and -2.02% for the 63 largest U.S. oil and gas firms. Further, carbon tax news prompted a market response of -0.52%. The press later 'discovered' the 2009 article and produced hundreds of stories between 2012 and 2013. The later publications prompted small negative market responses of approximately -0.02%. However, the later stories did produce a delayed reaction in the two weeks following their publication, with abnormal returns of -0.29%. Overall, the results indicate rational responses and efficient markets, with investors responding to the relatively obscure 2009 new article; later publications were relatively unimportant, as the publications contained little new information. For European energy utilities, Chapter 6 expects the market to anticipate the regulatory change and have an immediate reaction surrounding the early voting stages.

Equally, Griffin et al. (2015) also showed that the impact of regulatory changes may not be immediately realised by the market and may exhibit a delayed reaction. One explanation may be that regulatory changes are difficult to process, resulting in hard-to-value stocks. Kumar (2009) finds that individual investors make larger investment mistakes and exhibit stronger behavioural biases with hard-to-value stocks and greater market level uncertainty. Further, disposition, the reluctance to realise losses and overconfidence biases are often stronger for these stocks.

Overall, results suggest that environmental regulations and information regarding environmental objectives can impact financial return. The impact is negative if the regulatory changes are perceived to increase financial costs, but positive if they encourage innovation and efficiency. The anticipation and market reaction surrounding a regulatory change is likely to be dependent on the informational content contained within the regulations, with a differential impact across the four main restructuring streams (see Section 2.2). The following section examines how risk factors and policy may impact the systematic and firm-specific component of returns over time.

3.3.4 Structural Breaks and Break Point Tests

3.3.4.1 Theoretical framework

Based on the assumption of stationarity in time series, it is often assumed that the parameters of a model, such as mean, variance and trend, must remain constant over time despite little economic rationale to support this (Chow, 1960, Andrews, 1993). If the economic relationship is the same then the returns can be represented by the same regression model. However, the prior asset pricing literature in Sections 3.2 has found that the estimated relationship among industry returns and risk factors is not stable across time, with temporal sensitivity which affects significance (Huang et al., 1996, Fama and French, 1997, Faff and Brailsford, 1999, Sadorsky, 2001, El-Sharif et al., 2005, Boyer and Filion, 2007, Oberndorfer, 2009a). Subsections within Chapters 4 and 5 will examine the inter-temporal variability in model parameters and its implications on asset pricing. Chapter 4 will utilise an existing deductive inter-temporal analysis from the energy economics literature (El-Sharif et al., 2005), though this approach is subject to criticisms. Accordingly, Chapter 5 will apply the inductive Bai and Perron (1998; 2003) structural breakpoint tests to the energy utility sector.

The majority of the preceding literature uses the deductive approach, testing whether model parameters change surrounding key events. Section 1.3 shows that a key objective of this thesis is examining whether the relationship between average energy sector return and risk factors are stable through sector restructuring. Model stability can be examined using tests of structural breaks concerning *known* break dates (deductive) and *unknown* break dates (inductive). This thesis utilises both inductive and deductive approaches.

Consider a basic regression specification, where $y_t = \alpha + \beta x_t + e_t$, where $Ee^2 = \sigma^2$ and e_t is a time series of serially uncorrelated innovations. The model parameters are α, β and σ^2. If at least one of these parameters has changed at some date – known as the *break date* – then a *structural break* has occurred (Hansen, 2001). Structural breaks can affect the results of the model in a number of ways. First, a change in β indicates a change in the relationship with the risk factor, which affects expected y_t. A change in intercept, α, will affect the mean y_t. Finally, any change in e_t must affect the estimation of variance in the sector and the firm-specific component returns after filtering out systematic components (Fama and French, 1993, Hansen, 2001). These shifts in parameters are important with regard to isolating the firm-specific component of returns (see Chapter 5, Section 5.4.2.4).

Chow (1960) develop a test which examines whether two sets of observations can be regarded as belonging to the same regression model. Let y be a dependent variable and $x_1, x_2, \dots, x_p$ be independent variables, β a vector of estimated coefficients and e to be independent and normally distributed error terms with a mean of zero and standard deviation of σ. It is possible to test whether any additional observations, *H*, are from the same regression as the first sample, *T*, by testing whether the coefficients are identical. Put simply, if we expect that observations H are from the *same* population as observations T, then their estimated coefficients will be identical. If observations H are from a *different* population as observations *T*, their estimated coefficients will be significantly different. First, take sample 1 with *T* observations,

$$y_1 = X_1\beta_1 + e_1, \tag{3.4}$$

where y_1 and e_1 are column vectors with T elements, X_1 is a $T \times p$ matrix and β_1 is a column vector of the p regression coefficients. The least squared estimation is given by

$$b_1 = (X_1'X_1)^{-1}X_1'y_1 = \beta_1 + (X_1'X_1)^{-1}X_1'e_1, \tag{3.5}$$

where $(X_1'X_1)$ is the cross-product of the p x's in sample 1. Then sample 2, with H additional observations, is specified as

$$y_2 = X_2\beta_2 + e_2 \tag{3.6}$$

where X_2 is a $H \times p$ matrix, with H representing the H new observations of the p explanatory variables. By forming the difference between the vector y_2 and a vector of predicted observations based on the regression estimated using T observations, Chow (1960) incorporates (3.5) and (3.6), giving rise to

$$d = y_2 - X_2 b_1 = X_2 \beta_2 - X_2 \beta_1 + e_2 - X_2 (X_1' X_1)^{-1} X_1' e_1. \tag{3.7}$$

Therefore, the expectation of the difference, d, between vectors is

$$E(d) = X_2 \beta_2 - X_2 \beta_1. \tag{3.8}$$

If there is no difference between the vectors, then they must be from the same sample; however, if there is a difference between the vectors, then the observations must be independent of each other. Put simply, suppose that we expect the relationship between returns and risk factors for the energy utility sector to shift after a regulatory change, occurring during time period H, then it is possible to test whether the coefficients during the time period H are significantly different to the remainder of the time series (T). However, the limitation of the Chow (1960) test is the reliance on *a priori* knowledge of the known break dates to accurately implement an F-test on the significance of a regime change or intercept shift. Implicitly, the use of an *a priori* break date assumes that the market reacts on the break date which is not always appropriate – as shown in Chapter 6.

Quandt (1960) adjusts the Chow framework to relax the assumption of a known break date. Using likelihood ratio and F-tests, Quandt (1960) tests the hypothesis that no break occurs in the parameters of a linear regression model against the alternative hypothesis that one unknown break occurs over all possible break dates. The method relies on arbitrarily dividing the observations into two groups: one of the entire sample and one which includes the suspected break date. The null will be rejected if either of the observed mean residuals are significantly different from zero. The criticism of this method is that construction of the second sample is guesswork and therefore likely to be invalid. In most cases, the inclusion of surplus observations which are not affected by structural breaks will skew the mean residuals towards the expected value of zero, reducing the power of any statistical tests and biasing the results against significance.

Andrews (1993) proposes a test for a one-time change in the value of a parameter vector. Tests of structural change are considered under two conditions: 1) when the change point is specified to lie within some interval, and (2) when the change point is completely unknown. Furthermore, the tests can be implemented in the case of a ‘pure’ structural change, where the entire parameter changes, and for the case of ‘partial’ change, where only a component of the parameter vector changes. Consider a one-time structural change alternative hypothesis where the break point is denoted $\pi \in (0,1)$, where T is the sample size and $T\pi$ is the time of change. For example, one might want to test structural change occurring during the GFC, where the start and end date are known. The one-time alternative hypothesis is simple, as the test is H_0 versus $H_{1T}(\pi)$.

When the break point is known, it is possible to form either a Wald (1942), Lagrange Multiplier (LM) or Likelihood-ratio (LR)-like test for the null hypothesis of no break versus the alternative of one break (Andrews, 1993). In such a case, the tests are equivalent to the F tests commonly referred to as the Chow (1960), dummy variable or intercept shift-tests, where:

$$H_{1T}(\pi){:}\, \beta_t = \begin{cases} \beta_1(\pi) \text{ for } t = 1, \dots, T\pi \\ \beta_2(\pi)\text{for } t = T\pi + 1, \dots \end{cases} \tag{3.9}$$

for some constants $\beta_1(\pi), \beta_2(\pi) \in B \subset R^p$. However, testing for breaks between date intervals or unknown breaks complicates test statistics, as the break point parameter π is only considered under the alternative hypothesis and not under the null, unlike (3.9). Therefore, there is a need to construct a test statistic that does not take π as a given (Andrews, 1993).

Consider a major regulatory event where the timing of impact is unknown but expected to occur within or around a restricted interval. The exogenous event has the potential to cause structural change either: 1) after a lag of unknown length, or 2) before the event due to market anticipation (Andrews, 1993). In the case of this thesis, this is complicated further by the protracted European legislative process, where four key event dates are identified per legislation (see Section 2.1). Around all key dates it is possible for information to diffuse into the market. Further, the market may exhibit a lagged response due to hard-to-process information, as found by Griffin et al. (2015). In such cases, the test statistics centres on a break point occurring within a known structured interval, defined as $\prod \subset (0,1)$. The interval, for example, using the days following the announcement of the 2nd position (see Section 2.1), is subjected to Type II errors (false negative) if the market anticipates the regulatory change early. These concerns are extended further when there is no information regarding a potential break point, where all possible observations are of interest. Moreover, the examination of structural change is complicated further if there is no abrupt change in stock valuation, for example, shifting from one regime to a another with an interim transition period (Andrews, 1993). Overall, the deductive dummy variable method outlined previously will only be useful if we can be certain that the impact occurs within the restricted interval.

The inductive approach can overcome many of the misspecification criticisms of the deductive approach and allows examination of structural change where the break point is entirely *unknown*. Accordingly, Andrews et al. (1996) begin developing tests for one or more break points which occur at unknown time in a multiple linear regression model, considering the break point vector which only occurs under the alternative hypothesis.

Bai and Perron (1998, 2003) represent the most important contributions in this field, publishing theoretical and empirical papers with regard to estimating unknown structural break points. The papers focus on two problems: 1) estimating break dates, and 2) forming confidence intervals. Regarding the latter, the benefit of the Bai and Perron (2003) approach is that the data and errors may have heterogeneous distributions across segments. Consider the model:

$$y_t = x'_t\beta + z'_t\delta_j + u_t \quad t = T_{j-1} + 1, \dots, T_j \tag{3.10}$$

for $j = 1, \dots, m + 1$. Where y_t is the dependent variable at time t, x_t $(p \times 1)$ and z_t $(q \times 1)$ are vectors of covariates and β and δ_j are coefficients, respectively; u_t is the disturbance at time t. The break points, $(T_1, \dots, T_m)$, are unknown, where $T_0 = 0$ and $T_{m+1} = T$. The Bai and Perron (2003) test is designed to estimate the unknown regression coefficients and break points when T observations on the parameters y_t, x_t and z_t are available. Similar to ordinary least squares (OLS), the associated least-squares estimates of β and δ_j are obtained by minimising the sum of square residuals to estimate, as accurately as possible, the true value of the parameters, where the minimisation is taken over all partitions (break points) in the data.

Bai and Perron (2003) achieve this goal by developing an algorithm based on the principle of dynamic programming, allowing computation of estimates of the break points as global minimisers of the sum of squared residuals. The algorithm utilises previously forgotten dynamic programming of pure structural change models for a more general partial structural change model. Specifically, partitioned regressions and cluster analysis, curve fitting by use of segmented straight lines (polygonal curves) and grouping for maximum homogeneity by minimising variance within groups (see, respectively, Guthery, 1974; Bellman and Roth, 1969; Fisher, 1958).

The computation of estimates is achieved by applying OLS segment by segment without constraints, sequentially storing the sum of squared residuals (SSR). Once the SSR is stored, a dynamic programming approach can evaluate which partition achieves global minimisation over the overall SSR. The process begins by evaluating the optimal one-break partition for all sub-samples, storing the optimal one-break partition and associated SSR. The second step searches for optimal partitions with two breaks. For each end date, the procedure examines which one-break partition can be reinserted to achieve minimal SSR. The method continues sequentially, until optimal break partitions are obtained. Finally, the method compares which set of break partitions yields the lowest overall SSR when combined with additional segments.

The method can also be applied in the case of partial structural change. Using an iterative process, the algorithm minimises the SSR for the coefficients β and θ, where $\theta = (\delta, T_1, \dots T_m)$. The algorithm first minimises SSR with respect to θ keeping β fixed, and then minimises for β keeping θ fixed, then iterates assuring a decrease in the objective function. The iterations are important, as estimates of β will deviate from true values unless δ is already close to its true value, which is unlikely. Overall, the dynamic algorithm reports the date of break points for parameters of the regression model, partitioning the data into distinct time periods.

The Bai and Perron (1998; 2003) break point test has been implemented in a variety of situations within finance, energy economics and econometrics. This method will be implemented in Chapter 5 to identify significant changes in the parameters of the AFFM through time using an inductive approach. Further, the break point test is also utilised when isolating the firm-specific component of returns. The following section outlines some empirical applications of the model.

3.3.4.2 Empirical applications of inductive structural break point tests

To date, no paper examines the evolving systematic risk of European energy utilities throughout sector restructuring. Further, none of the literature in Sections 3.2.2 or 3.2.3 use inductive methods to control for structural breaks. Of the few tests of structural change, all assume known break dates. The following paragraphs outline empirical applications of the Bai and Perron (1998, 2003) structural break point test on multivariate models or volatility of stock returns.

Bai and Perron (2003) is the first paper to empirically apply the structural break point test, employing the test to re-evaluate two prior break point papers: Garcia and Perron (1996) and Alogoskoufis and Smith (1991). The first application addresses Garcia and Perron (1996), who examine structural breaks in the U.S. *ex-post* real interest rates using quarterly data between 1961 and 1986. The main results of Garcia and Perron (1996) find two abrupt structural breaks in U.S. interest rates. Bai and Perron’s (2003) re-examination detects the existence of a smaller third structural break. Bai and Perron (2003) conclude that their procedure is more powerful than previous regime switching methods due to the error distributions being allowed to differ across partitions. The second application of Bai and Perron (2003) re-evaluates Alogoskoufis and Smith (1991), who examine structural breaks in the UK post-war inflation rate and the Phillips curve between 1947 and 1987. Alogoskoufis and Smith (1991) argue the existence of a one-time structural break in the series from 1967 to 1968. Bai and Perron (2003) empirically confirm the existence of the 1967 structural break. Their results also detect a second break in 1975. The conclusion is that the structural-shift in inflation is short-lasting, between 1967 and 1975. Post-1975, inflation rates returned to pre-shift levels.

Chen and Chen (2007) utilise cointegration analysis to examine the long-run relationship between real oil prices and exchange rates between 1972 and 2005, using data from the G7 countries. The Bai and Perron (1998, 2003) test of structural change is implemented as a preliminary analysis to identify whether oil prices and exchange rates may have been affected by major events. Chen and Chen (2007) find that both French and German real exchange rates experienced one structural break each during the time series and incorporate these structural breaks to improve the precision of cointegration analysis.

Lettau et al. (2008) examine shifts in volatility and mean of consumption growth to calibrate a rational asset pricing model, using the Bai and Perron (2003) test as a robustness check. The results show the presence of structural shifts in the data. Lettau et al. (2008) later show that there is strong correlation between the low-frequency movements in macroeconomic volatility and asset prices in post-war data. The structural break test is utilised to detect a shift in price to earnings or dividends, where the results indicate a persistent shift well above their historical norms.

Narayan and Smyth (2008) utilise the Bai and Perron (2003) test to identify structural breaks in the relationship between capital formation, energy consumption and real GDP in G7 countries. Narayan and Smyth (2008) report mixed findings from the existing literature, but identify that a limitation of previous studies includes the failure to account for the frequent expected structural breaks in the relationship between energy consumption and GDP. After accounting for structural breaks, there is a long-run equilibrium relationship between the variables which would have otherwise been obscured in the data, finding that capital formation and energy consumption Granger-cause GDP.

Finally, Brandt et al. (2009) also utilise the Bai and Perron (2003) test to identify structural breaks in idiosyncratic volatility between 1925 and 2008. Their motivation for using the break point test comes from their descriptive statistics, which show that volatility trends depend on the estimation time period used. Superficially, there is a time trend of increasing idiosyncratic volatility between 1962 and 1997. The Bai and Perron (2003) test detects multiple break points in the series, including 1975, 1994, and 2000. Importantly, the 2000 break point coincides with theory, where volatility during the 1990s is consistent with an episode that later reversed itself post-2000; the break point test formally confirms this proposition.

An observations of the research above is that the empirical tests are implemented over long time horizons, sometimes over several decades. As argued in Section 3.3.4, there is little economic rationale to assume the estimated parameters will remain stable over such a long period. Following the research above, this thesis will implement the Bai and Perron (1998, 2003) structural break point test to identify changes in the relationship between returns and risk premia through time.

3.3.5 Methodological Issues of Measuring Effects on Valuation

As stated in 3.1, there are methodological issues and caveats which are expected to plague asset pricing models. Section 3.3.5.1 outlines the use of a panel versus portfolio approach to analysis, while Section 3.3.5.2 focuses on the potential impact of effective hedging strategies on estimated coefficients; the section also addresses commodity speculation.

3.3.5.1 Utilising a panel or portfolio approach

For empirical analysis, we are able to utilise either a panel or a portfolio approach for the multifactor asset pricing models and the event study approach. Traditionally, the portfolio approach is favoured from a finance perspective. This is primarily due to the fact that the panel approach can often lead to inflated t-statistics. Schwert (1981) argues that the *t* statistic, which provides the test of significant impact, for an individual asset is

$$t_i \equiv \frac{\epsilon_{it}}{S(\epsilon_i)} = \frac{(R_{it} - \bar{R}_\iota)}{S(R_i)} \frac{\sqrt{T}}{\sqrt{T+1}}, \tag{3.11}$$

where R_{it} is the return on asset i at time t, $\bar{R}_i$ is the historical average return on asset i and $S(R_i)$ is the historical standard deviation of return of asset i based on T observations. However, since returns within an industry are likely to be positively correlated, the impact of a regulation cannot be assessed on individual assets; if one t-statistic is large by chance, then it is also likely others will be large too (Schwert, 1981).

To examine the impact of any regulatory change, the objective of Chapter 6, securities must be grouped into portfolios based on similarity of impact. This is important as a new regulation can transfer wealth from one half of the sector to the other firms within the same sector. The net impact on a sector will be null, despite the fact that individual firms experience large gains and losses (Schwert, 1981). The portfolio approach allows examination of the differential impacts on potential gainers and potential losers. The portfolio test statistic becomes:

$$t_p \equiv \frac{\epsilon_{pt}}{S(\epsilon_p)} = \frac{(R_{pt} - \overline{R_p})}{S(R_p)} \frac{\sqrt{T}}{\sqrt{T+1}}, \tag{3.12}$$

where the portfolio abnormal return (R_{pt}) is a weighted average of individual abnormal returns, but the standard deviation of the portfolio, $S(R_p)$, is less than or equal to the weighted combination of individual assets' standard deviations (Markowitz, 1952, Schwert, 1981). This common approach to estimating parameters also reduces the errors-in-variables problem (Banz, 1981, Schwert, 1981), while adopting a value-weighted approach minimises variance and captures return behaviours in a manner that relates to realistic investment opportunities (Fama and French, 1993).

Schwert (1981) also argues that a regulation can also result in correlated residuals in a cross-sectional regression, where the estimated standard errors of a regulatory dummy variable, such as those used in the case of a known break date, are biased downwards and the significance tests are biased towards rejecting the null. This argument is similar to Chan et al. (1985), who argue that any cross-sectional regression forces the intercept term of the model, as well as the risk premiums, to be the same across all companies. Note, this assumption must also assume that the coefficient is the same over time; a proposition tested in Chapters 4 and 5. Therefore, any violation of the pricing equation, deviations from predicted values, will be absorbed by the residuals. This latter point is addressed in Section 5.4.2.4. Any omitted variables from the model specification will also bias the estimates of regression coefficients, while inter-correlated disturbances will bias standard errors. Both effects result in false positives, spurious effects of regulation. Such specification issues are important as Chan et al. (1985) highlight that the residuals of the asset pricing model, assuming correct specification, are often interpreted as the risk-adjusted returns – necessary for the calculation of abnormal returns induced by regulation in Chapter 6.

Based on the arguments above, this thesis opts to implement a time-series and portfolio approach which has typically been implemented by the majority of the finance literature outlined in Section 3.2.2. Energy utilities are grouped into portfolios based on similarity of characteristics to examine differential impacts of risk factors and changes in financial return as a result of regulatory changes.

3.3.5.2 Speculation and hedging

As with any empirical analysis, there are a range of behaviours which may bias the results against finding significance. As mentioned previously (see Section 3.2.3), the ability to speculate or hedge can alter endogenous risk exposure. Further, hedging and the ability to pass costs onto end consumers will bias the results against statistical significance. Finally, energy utilities can merge and benefit from economies of scale and transmission line ownership. While it is not possible to control for all confounding effects, it is important to acknowledge that they exist and may affect results. The following sections outline research relating to these matters.

If the European energy utility sector is indeed exposed to changing market risks through liberalisation and environmental objectives, then what strategies are available to the average energy utility company to alter their endogenous risk profile? Endogenous risk profiles can be altered through two methods: *speculation* or *hedging*. Being a dynamic market, across multiple operations, the energy sector may exhibit behaviours consistent with either of these methods.

Söderholm (1998) also finds results consistent with the notion that European electricity utilities are able to substitute fuels in the short term, particularly multi-fuel fired plants. This substitution of fuels allows utilities to exploit fuel price differences and gives energy utilities negotiating power (Söderholm, 2001). Fuel switching can occur as quickly as one day if the alternative fuel is available, provided the generator can burn the fuel, or modifications can occur within weeks or months. For example, Austria's coal/gas-fired plants, which operatured under long-term coal contracts, have been known to burn gas when gas prices are low and stockpile coal for future periods (Söderholm, 2001). Further, oil/gas-fired plants under long-term gas contracts can quickly switch from gas to oil if the spot price for gas increases above the long-term contract price (Söderholm, 2001). Crucially, this ability of some multi-fuel generators to switch fuels results in fuel suppliers facing a fuel price ceiling, as any large price increase will incentivise the multi-fuel generators to sell fuels, thus providing excess supply and reducing price. Clearly, these mechanisms allow an energy company to speculate on the price of fuel. Equally, concern has been raised that commodities may be overshooting market fundamentals due to speculative expectations from investors who buy commodities as a financial asset (Kaufmann, 2011). This is a pressing concern, as Diaz-Rainey et al. (2011) argue that European energy utilities are increasingly relying on spot markets for energy sources. This potentially exposes energy utilities to much greater commodity risk, particularly if the firm is unable to effectively hedge commodities, for example, distressed firms.

While the preceding paragraph highlights increased risk exposure from speculation, fuel hedging can also decrease risk exposure. In a regulated market, any spike in the price of inputs for gas producers can be passed through to the end consumer with an additional supply charge. However, in a liberalised market there is competition, where suppliers will compete on price, thus reducing the elasticity of the end product's price (Gual, 1999). Any shocks to input price must be absorbed by the energy utility, reducing net profits. Highly volatile returns result in a higher cost of capital to investors; therefore, there is an economic incentive to mitigate this supply shock.

Haulshalter (2000) investigates evidence of hedging behaviour in the returns of the 100 oil and gas producers against price fluctuations in exchange-traded commodities, between 1992 to 1994. Results show that the ratio of hedging increases as the financial leverage, a proxy for risk, increases within a company. Therefore, it can be expected that if some energy utilities experience periods of increased risk and input-price volatility, then they will be more likely to hedge to reduce financial contracting costs. However, Haushalter (2000) finds that gas hedging varies from zero to 97.5% in the oil & gas sector, indicating that risk management practices are not uniform across the sector.

Some electricity generators openly report the profit or losses made on hedging contracts, broken down by commodity, and also indicate the use of future and swap contracts (EDF, 2009). In contrast, some companies are relatively ambigious about their hedging activities, simply reporting ‘fair value hedge adjustments’ (EDP, 2009). The hedging appears to manifest as hedging the supply shock of commodities. As the methods of hedging and transparency of reporting differ between operations and companies, hedging is uncontrollable in the case of this thesis. However, it is a theoretical point that is highlighted to explain any lack of significant relationship between the energy sector and commodities known to be used in energy production, for example, coal and natural gas.

Having placed the thesis in the context of the existing finance and energy economics litrature, the next three chapters present the empirical contributions of the theisis.

CHAPTER 4

RISK FACTORS IN ENERGY UTILITY RETURNS: AN AUGMENTED-FOUR-FACTOR MODEL (AFFM)

4.1 Introduction

A central theme in finance and energy economics literature is examining the relationship between risk and return. The European equity market has been influenced by global macroeconomic events such as the dot-com collapse of 2000, the GFC of 2007 to 2009 and the EUC of 2010 to 2011. As a result, the valuation of all European stocks has been characterised by large price changes and associated fluctuations in interest rates which reflect changing economic conditions. The effects of financial crises extend beyond equity and commodity prices. The GFC also resulted in energy demand decreasing by 4.9% in the first quarter of 2009 (IEA, 2009). Simultaneously, there have been dramatic changes in the price of energy-related commodities, with record high prices for oil, natural gas and coal in the last decade (Oberndorfer, 2009a). Equally, concern has been raised that commodities may be overshooting market fundamentals due to speculative expectations from investors who buy commodities as a financial asset (Kaufmann, 2011). Institutional and retail investors are devoting more capital to commodity investments; a greater than 53-fold increase, from $6 billion to $320 billion, was recorded between 2000 and 2010 (The Economist, 2010). Moreover, an additional risk factor of the last decade, which is expected to affect all European firms, is the implementation of the EU ETS, introducing carbon price risk.

Given the importance of energy utilities to the economy and the transition to a decarbonised energy system (see Section 1.2), this chapter is principally concerned with the impact of all these risk factors and changes on energy sector returns. Accordingly, this chapter addresses four research questions, previously shown in Section 1.1, namely: 1) to what extent do commodity price changes impact the returns in the European energy utility sector, 2) could stock-market risk factors better explain the variation in energy utilities' returns, 3) do the impacts reflect market-wide conditions or the sector-specific relationships between returns and risk premia and 4) are these risk premia time-varying?

In order to address these questions, this chapter must first develop a superior asset pricing model to explain average returns in the European energy utility sector, as noted in the introduction (Section 1.5.1). The motivation for this is from the lack of sector-specific research which focuses on asset pricing in European energy utilities, which is largely limited to Oberndorfer (2009a) and Koch and Bassen (2013). As noted in Section 3.2.2.5, El-Sharif et al. (2005) and Oberndorfer (2009a) both argue that the energy economics literature is relatively restricted due to its reliance on outdated asset pricing models, and both authors suggest that incorporating standard finance risk factors is an avenue for future research. This chapter addresses this niche by reintegrating the stock market risk factors of Fama and French (1993) and Carhart (1997) from the finance literature (Section 3.2.2) with the macroeconomic variables identified in the energy economics literature (Section 3.2.3). This chapter proposes the global AFFM, which extends the four stock market risk factors (market factor, size premium, value premium, and momentum premium) to include term premium and commodities previously found to affect energy utility sector returns (oil, coal, natural gas and carbon). This chapter uses the global AFFM to answer the four research questions above.

First, a comparison of the global AFFM and existing asset pricing models will explore whether the global AFFM is superior at capturing average returns in the energy sector. Second, the global AFFM will be used to answer research questions 1 and 2 of this chapter. The motivation for research question 3 of this chapter, the inter-sectoral analysis, extends from El-Sharif et al. 2005 and Faff and Brailsford (1999), who examine the macroeconomic risk exposure of multiple sectors. Similarly, Fama and French (1997) also examine risk exposure to stock market risk factors across multiple sectors. The global AFFM is implemented on an additional 10 European sectors to contrast against the energy sector, identifying whether the results for the energy utility sector are unique or observed across multiple sectors. This thesis also compares the estimated coefficients across sectors from the global AFFM to Faff and Brailsford (1999) and Fama and French (1997). The motivation for research question 4 of this chapter comes from the prior asset pricing literature in Sections 3.2 which has found that the estimated relationships among industry returns and risk factors are not stable across time, with temporal sensitivity which affects significance (Huang et al., 1996, Fama and French, 1997, Faff and Brailsford, 1999, Sadorsky, 2001, El-Sharif et al., 2005, Boyer and Filion, 2007, Oberndorfer, 2009a). This chapter builds on El-Sharif et al. (2005) to employ conditional annual global AFFM regressions which explore the inter-temporal relationship between energy sector returns and risk premia, answering research question 4.

This chapter makes multiple contributions to the literature. In line with the more general contributions of the thesis, and as mentioned in Sections 1.5.4 and 3.3, this thesis constructs a superior European energy utility sample. Specifically, the sample of 88 energy utilities is considerably larger than that of Oberndorfer (2009a) and Koch and Bassen (2013), who examine 22 and 20 European energy utilities, respectively. The chapter constructs a comprehensive sample that includes natural gas and electricity utilities (thereby reflecting the focus of EU policies). The sample is derived from the EU legislation which mentioned the firms impacted and through membership of professional association. Further, the inclusion of non-active companies controls for survivorship bias, an improvement over Oberndorfer (2009a) and Koch and Bassen (2013).

In addition to these more general thesis contributions, there are chapter-specific contributions to the literature. First, this chapter employs a full-scale asset pricing test for the European energy utility sector, extending Oberndorfer (2009a) and Koch and Bassen (2013). Second, while the three-factor model has been implemented on the oil & gas sector by Elyasiani et al. (2011), to date, no authors have implemented the three- or four-factor models (see Sections 3.2.2.3 and 3.2.2.4, respectively) on the European energy utility sector. Accordingly, this chapter serves to fill this niche. Third, this chapter examines returns between 1996 and 2013. This is an improvement over El-Sharif et al. (2005) and Oberndorfer (2009a) by including the GFC and third packages of liberalisation – expected to be a major regulatory reform in the sector (see Section 2.2.1). Further, this extends Koch and Bassen (2013) by including the EUC. Fourth, the use of 10 European sectors is an improvement over El-Sharif et al. (2005), who examines four additional European sectors.

The remainder of this chapter is structured as follows. Section 4.2 outlines the empirical approach, sample and data used in the analysis. Section 4.3 presents the results of this chapter, delineated into descriptive results (Section 4.3.1) for context and econometric results (Section 4.3.2) to address the research questions. Section 4.4 concludes the chapter, highlighting chapter contributions and limitations.

4.2 Methodology

The following section (4.2.1) outlines the empirical models used to address the research questions in Section 4.1. The sample used is addressed in Section 4.2.2, while data is addressed in Section 4.2.3. The calculation of the stock market risk factors from the finance literature is outlined in Section 4.2.4.

4.2.1 Models and Econometric Approach

The following outlines the asset pricing models used to address the four research questions of this chapter. The four asset pricing models implemented in this chapter are the CAPM, augmented-CAPM, four-factor model and the proposed global AFFM, outlined in the literature review (Section 3.2). For convenience, sector portfolio returns are denoted in the generalised form $\boldsymbol{R}_{i,t}$, where $\boldsymbol{R}_{i,t}$ denotes the excess returns[42] over the one month UK treasury bill rate on the i^{th} portfolio on day t (see Section 4.2.3.1). The econometric modelling begins with the CAPM from Section 3.2.1, estimated using OLS regressions, and gradually builds the global AFFM. The CAPM estimates a market beta based on the relationship between the excess returns of the sectors and the market factor, specified as:

$$\boldsymbol{R}_{i,t} = \alpha_i + b_i \boldsymbol{R}_{m,t} + e_{i,t}, \tag{4.1}$$

where α_i denotes the intercept, b_i denotes the market factor coefficient, $\boldsymbol{R}_{m,t}$ denotes the excess return on the market factor at time t and $e_{i,t}$ is the error term of portfolio i at time t. The second model specification is the augmented-CAPM from the energy economics literature (see Section 3.2.3). The energy economics literature extends the CAPM to include a variety of macroeconomic variables expected to affect returns in the energy sector, including term premium and commodity risk factors. The specification is:

$$\boldsymbol{R}_{i,t} = \alpha_i + b_i \boldsymbol{R}_{m,t} + tp_i \boldsymbol{R}_{tp,t} + o_i R_{o,t} + c_i R_{c,t} + g_i R_{g,t} + e_{i,t}, \tag{4.2}$$

where tp_i denotes the term premium coefficient, $\boldsymbol{R}_{tp,t}$ denotes the term premium at time t, o_i denotes the oil price risk coefficient, $R_{o,t}$ denotes the return on oil price at time t, c_i denotes the coal price risk coefficient, $R_{c,t}$ denotes the return on coal price at time t, g_i denotes the natural gas price risk coefficient and $R_{g,t}$ denotes the return on natural gas price at time t.

While some energy economics authors (Faff and Brailsford, 1999, Sadorsky, 2001, El-Sharif et al., 2005, Boyer and Filion, 2007, Ramos and Veiga, 2011) include exchange rate risk, many finance papers exclude exchange rate risk or find exchange risk to be an insignificant risk factor (Manning, 1991, Fama and French, 1992, 1993, 1995, Carhart, 1997, Fama and French, 2012). This produces a potential inference problem if purchasing power parity are heterogeneous or assets can be used to hedge exchange risk. The majority of papers that use exchange rate risk focus on oil and gas exporting countries in an international context, which suggests that the industry may be sensitive to international currency fluctuations (Sadorsky, 2001). As the majority of countries in the European Union operate under a single currency, this obstacle is overcome by converting all variables (where possible) to the common currency euro (€), implicitly controlling for exchange rate risk. Further, all data and the commodity risk factors are from European-specific data sources and therefore represent European costs.

---

[42] Note, the notation of excess return in this thesis is consistent with Koch and Bassen (2013) and Oberndorfer (2009a) from the energy economics literature. In the finance literature, excess return is typically denoted $(R_{i,t} - R_{f,t})$, where $R_{i,t}$ denotes the change in equity price in day *t* and $R_{f,t}$ denotes the risk-free rate on day *t*. Both measures of excess return are identical. In this thesis, a bold parameter identifies return in *excess* of the risk free rate.

For the third model, the finance literature develops an asset pricing model to improve the estimation of the systematic risk component of a stock's returns (see Section 3.2.2). Fama and French (1992) find that Equation (4.1) is underspecified, as the market beta estimate in the CAPM has low power for small and high-BE/ME stocks and is insufficient at explaining a cross-section of expected stock returns. The CAPM in Equation (4.1) is extended to include additional stock market factors to produce the four-factor model specification:

$$\boldsymbol{R}_{i,t} = \alpha_i + b_i \boldsymbol{R}_{m,t} + s_i SMB_t + h_i HML_t + m_i UMD_t + e_{i,t}, \tag{4.3}$$

where s_i denotes the size premium coefficient, SMB_t denotes the size premium at time t, h_i denotes the value premium coefficient, HML_t denotes the value premium at time t, m_i denotes the momentum premium coefficient, and UMD_t denotes the momentum premium at time t. The global stock market risk factors are calculated over a diverse sample of 600 European stocks (see Section 4.2.4).

The four-factor model is augmented to include commodity risk factors from the energy economics literature, leading to the main contribution of this chapter, namely, the global AFFM. The name is derived from the inclusion of four stock market factors, augmented by term premium and commodity risk factors. The resulting specification is:

$$\begin{aligned}\boldsymbol{R}_{i,t} = {} & \alpha_i + b_i \boldsymbol{R}_{m,t} + s_i SMB_t + h_i HML_t + m_i UMD_t + tp_i \boldsymbol{R}_{tp,t} \\ & + o_i R_{o,t} + c_i R_{c,t} + g_i R_{g,t} + e_{i,t},\end{aligned} \tag{4.4}$$

which controls for stock market, term premium and commodity risk factors. The relatively short time series for carbon prices results in its exclusion at this stage of analysis. All equations, (4.1) to (4.4), will be compared inter- sectorally and estimated using Newey-West Heteroskedasticity and Autocorrelation (HAC) standard errors and subject to standard regression diagnostic tests. Consideration was given to the use of a GARCH model specification to control for heteroskedasticity, but Oberndorfer (2009a), who implemented the augmented-CAPM on European energy utilities and oil & gas firms, found no difference between an OLS and GARCH specification. In the time-series regressions, coefficients and R^2 values are direct evidence of the ability of the specified risk factors in capturing common variation in returns (Fama and French, 1993). Accordingly, the goodness of fit will be determined by comparing adjusted R^2 values and the significance of variables. Implementing Equation (4.4) on the energy utility sector will address research questions 1 and 2. Implementing Equation (4.4) across sectors will address research question 3.

As noted in Section 3.3.4, the previous literature has shown that the estimated relationship between returns and risk factors is not stable across time, showing temporal sensitivity which affects significance (Huang et al., 1996, Fama and French, 1997, Faff and Brailsford, 1999, El-Sharif et al., 2005, Boyer and Filion, 2007). Therefore, the true slope of the risk factors is also likely to change across time. To address this issue, Equation (4.4) will also be implemented on an annual basis, similar to El-Sharif et al. (2005). Such conditional models are not expected to increase regression fit (Fama and French, 1997). However, temporal models provide useful insight into the evolving return profile of European stock returns. Further, the annual regressions allow the inclusion of carbon price risk from 2006 onwards, contributing to research question 1. Accordingly, the following specification is implemented on an annual basis between 1996 and 2013:

$$\boldsymbol{R}_i = \alpha_i + b_i\boldsymbol{R}_m + s_iSMB + h_iHML + m_iUMD + tp_i\boldsymbol{R}_{tp} + o_iR_o + c_iR_c + g_iR_g + co2_iR_{co2} + e_i, \quad (4.5)$$

where $co2_i$ denotes the carbon price risk coefficient and R_{co2} denotes the return on carbon. The conditional annual global AFFM regressions in Equation (4.5) address research question 4.

Consideration was given to implementing a rolling regression approach using the past five years of data, as Fama and French (1997) argue that a period-by-period approach can lead to imprecise risk loading estimates. The rolling regression is beneficial if the true slopes remain stationary. Any permanent changes in supply or demand conditions result in permanent changes in risk loading (Fama and French, 1997). Further, the rolling regression approach consumes the first five years of observations, omitting the first major packages of liberalisation for electricity and gas utilities which occur in 1996 and 1998, respectively (see Section 2.2.1). As the European energy utility sector is currently being restructured, permanent shifts in risk factor loadings are expected. Moreover, the first packages of liberalisation are pertinent to later chapters of this thesis which measure the impact of regulatory changes (Chapter 6). Therefore, the rolling regression approach is not suitable for analysis.

4.2.2 Sample Selection

The STOXX® 600 Europe Utilities index is used to provide an initial list of 28 European utilities currently operating and traded on equity markets. All utilities whose primary revenue is derived from waste or water operations are removed from the sample as these firms may bias estimated coefficients. The sample is expanded by including all companies explicitly mentioned in energy sector restructuring legislation, outlined in Section 2.2 and Table 2.1. This includes electricity utilities identified as elected members of the European Distribution System Operators' Association (EDSO), ENTSO-E, or mentioned in annexes in the electricity-specific legislation of Table 2.1. Moreover, utilities operating in the natural gas industry are also identified by their membership in Gas Infrastructure Europe (GIE), Gas Transmission Europe (GTE), Gas Storage Europe (GSE), Gas LNG Europe

(GLE), ENTSO-G, Eurogas and the annexes of the natural gas–specific legislation of Table 2.1.

For the newly formed sample, Standard Industrial Classification (SIC) codes are extracted from Datastream. Research Insight is used to expand the sample further by including all active and non-active energy utilities registered under the same product segments and SICs. The inclusion of non-active companies controls for survivorship bias, an improvement over Oberndorfer (2009a) and Koch and Bassen (2013). Screening for duplicate entries, the sample consists of 91 European energy utility companies across both the electricity and natural gas industries. Due to data requirements for portfolio formation, identified in Section 4.2.3, three companies were removed from the sample as some accounting data was unavailable, leaving 88 eligible energy utilities. As mentioned in the introduction (Section 4.1), the sample is still considerably larger than that of Oberndorfer (2009a) and Koch and Bassen (2013).

4.2.3 Data

The data are a combination of daily stock market and annual accounting data. All data are extracted from Thomson Reuters Datastream. The daily stock prices and market capitalisations of the energy utilities cover the period 30 June 1995 to 28 June 2013 (4,435 daily observations). The calculation of the momentum factor absorbs the first year of daily observations (251 days); therefore, the analysis uses the data from 01 July 1996 to 28 June 2013. The goal is to ensure the time series begins prior to the onset of major regulatory reforms in the European energy sector, as discussed in Section 2.2 and Table 2.1. Stock prices are measured in euros at day close and adjusted for capital actions, such as dividends, stock splits and mergers. Daily returns for all stocks and risk factors are calculated as the first-log difference of price. Excess returns are calculated as the difference between daily returns and the daily yield on the one-month UK Treasury bill. The UK Treasury bill is used as the risk free rate of return as European bonds did not have sufficient data.[43] Market capitalisation is also recorded at day close and measured in euros. Regarding the accounting data, all data are extracted for fiscal year-end, covering the period 1995 to 2013.[44] To be eligible for analysis, and to allow portfolio rebalancing, all firms must have data on stock price, market

---

[43] Consideration was given to using the Euro Interbank Offer Rate (EURIBOR), similar to Oberndorfer (2009a). However, only monthly data were available throughout the entire time series. The daily three-month and one-month EURIBOR rates were available from the 30th December 1998 and 4th January 1999, respectively. These dates exclude the first packages of liberalisation (Section 2.2.1), necessary for analysis in Chapter 6.

[44] At the time of writing this thesis, the 2014 accounting data were sparse and contained omissions, preventing the analysis from continuing beyond 2013.

capitalisation and book value of equity for both year t and year $t-1$. Similar to Fama and French (1993), this ensures that companies have traded for at least two years.

Term premium is calculated as the difference between the daily yields on the three- and one-month UK Treasury bills, denoted $\boldsymbol{R_{tp,t}}$. London Brent Crude Oil Index proxies for oil price, sourced from the Intercontinental Exchange (ICE), and oil returns are denoted $R_{o,t}$. Coal price is measured using a European-specific steam (thermal) coal index for power and heat generation,[45] sourced from the Hamburg Institute of International Economics (HWWI), and coal returns denoted $R_{c,t}$. Natural gas price is measured using the one-month forward index, also sourced from the ICE, and natural gas returns are denoted $R_{g,t}$. The natural gas price begins in 1996, another contributing factor in determining the start date of the empirical analysis. However, the 1996 start date is adequate to provide a broad coverage of energy sector returns while controlling for commodity risk factors. Carbon allowance prices, measured as the price (in euros) per EUA, are sourced from the ICE European Climate Exchange (ECX). The ICE ECX Futures is one of the most liquid, pan-European platforms for emissions trading. Continuous settlement prices are used to represent the market price of carbon.[46] Carbon returns are denoted $R_{co2,t}$. As stated in Section 4.2.1, the carbon series is only included in the inter-temporal analysis due to the relatively short time series.

The STOXX® 600 Europe index is used as a proxy for the broad market returns. The STOXX® 600 Europe index represents large-, mid- and small capitalisation firms across 18 countries of the European Union. Summary statistics regarding the 600 firms are provided in Table 4.1. The constituents of the STOXX® 600 Index are weighted towards firms listed in the UK, France and Germany. Across sectors, the index has approximately equal weighting with the exception of the industrial sector, which comprises 18.33% of the 600 firms.

---

[45] See discussion regarding the limitation of Oberndorfer's (2009a) composite coal index (Section 3.2.3.3).

[46] The transition between Phase I and Phase II of the EU ETS resulted in a price jump in EUAs from €0.01 to €20.88, 29 Feb 2008 to 03 Mar 2008, respectively. The associated return was 764.40%. This single observation was deleted and replaced with zero, as its inclusion resulted in unusual summary statistics and insignificant carbon risk exposure across all sector portfolios. Post-deletion, carbon risk exposure was detected, which was consistent with Koch and Bassen (2013). While carbon futures may have been preferable, sufficient data was unavailable. Consideration was given to using the ICE ECX continuous average settlement price, which minimises the large price change, but the series produced inconsistent results with the coal series. The method outlined above provided results consistent with theory, with minimal data manipulation, and was deemed the better option. From here on in, all data relating to carbon exclude the outlier observation described above.

TABLE 4.1: SUMMARY OF STOXX® 600 EUROPE CONSTITUENTS

This table provides a summary of characteristics for the 600 firms of the STOXX® 600 Europe index. The two characteristics include 1) country and 2) sector.

Country	**Obs**	**Percentage**	**Sector**	**Obs**	**Percentage**
Austria	7	1.17%	Automobiles & Parts	15	2.50%
Belgium	13	2.17%	Banks	47	7.83%
Czech Republic	2	0.33%	Basic Resources	19	3.17%
Denmark	20	3.33%	Chemicals	26	4.33%
Finland	16	2.67%	Construction & Materials	19	3.17%
France	84	14.00%	Financial Services	31	5.17%
Germany	63	10.50%	Food & Beverages	24	4.00%
Greece	4	0.67%	Healthcare	36	6.00%
Ireland	9	1.50%	Industrial Goods & Services	110	18.33%
Italy	31	5.17%	Insurance	38	6.33%
Luxembourg	4	0.67%	Media	29	4.83%
Netherlands	28	4.67%	Oil & gas	25	4.17%
Norway	13	2.17%	Personal & Household Goods	31	5.17%
Portugal	4	0.67%	Real Estate	25	4.17%
Spain	29	4.83%	Retail	29	4.83%
Sweden	38	6.33%	Technology	25	4.17%
Switzerland	48	8.00%	Telecommunications	22	3.67%
United Kingdom	187	31.17%	Travel & Leisure	23	3.83%
			Utilities	26	4.33%
Total	600	100.00%	**Total**	600	100.00%

Various econometric factors also influenced the choice of the market proxy. First, unless *every* asset can be included, the market proxy chosen should mimic the true market portfolio as close as possible (Roll, 1977). Accordingly, the 'Roll critique', notes that misspecification in the 'market' proxy will create an estimation bias, which can result in two portfolios, which are both mean-variance efficient, having different betas. The STOXX® 600 Europe index is the most relevant market factor with regard to the 11 sectors analysed, as all 11 sectors are drawn from the STOXX® 600 Europe index (see Table 4.1). Second, rather than use an established stock market index, Fama and French (1993) define their market factor to be a value-weighted combination of all firms eligible for analysis. Fama and French (1993) show that the market factor is typically good at explaining returns on big, low-BE/ME stocks. Naturally, these stocks dominate sector valuation. Fama and French (1993) also show that the additional stock market risk factors are buried within the market factor. The mimicking portfolios of size and value premium are designed to capture shared variation in stock returns that is missed by the market factor. The calculation of the size and value premia in Fama and French (1993) is performed using the same universe of companies as the market factor. Thus, to calculate the global stock market factors, this chapter adopts the same approach. The calculation of mimicking portfolios in Section 4.2.4 uses the universe of 600 companies in the STOXX® 600 Europe index as a proxy for European equities. This ensures that not only is the market factor applicable across all sectors, but the size, value and momentum premia calculated in Section 4.2.4 are also relevant across all 11 sectors. Note, this chapter calculates ‘global’ risk factors, while Chapter 5 calculates ‘local’ risk factors specific to the European energy utility sector; see discussion in Section 3.2.2.4 and footnote 8. Appendix A will compare variables and estimates from this thesis to existing literature to ensure congruence. The stock market and commodity risk factors outlined to this point address research questions 1 and 2.

4.2.3.1 Additional European Sectors

To address research question 3, the inter-sectoral analysis, Equations (4.1) to (4.4) are employed on an additional 10 European sectors. The additional 10 sectors, extracted from the STOXX 600 Europe index, include the bank, oil & gas, telecommunication, industrial, insurance, retail, technology, media, chemical and financial sectors. Excess returns are calculated using the method outlined in Section 4.2.3. The time series for all sectors are denoted: $\boldsymbol{R}_{util}$, $\boldsymbol{R}_{banks}$, $\boldsymbol{R}_{O\&G}$, $\boldsymbol{R}_{tele}$, $\boldsymbol{R}_{ind}$, $\boldsymbol{R}_{ins}$, $\boldsymbol{R}_{ret}$, $\boldsymbol{R}_{tech}$, $\boldsymbol{R}_{media}$, $\boldsymbol{R}_{chem}$ and $\boldsymbol{R}_{fin}$. Each sector will replace $\boldsymbol{R}_{i,t}$ in Equations (4.1) to (4.4), regressed independently. The comparison of the regression results reveals inter-sectoral differences regarding the impact of risk premia. The inter-sectoral analysis helps establish whether the results reported for the European energy utility sector reflect community-wide macroeconomic responses, or whether the results represent a sector-specific relationship between the risk factors and average sector returns. The use of 10 sectors is an improvement over El-Sharif et al. (2005), who only uses four additional sectors.

The 10 additional sectors were purposefully selected to represent a broad range of expected sensitivities to the various risk factors in the inter-sectoral analysis. The oil & gas, industrial and chemical sectors were chosen as they are energy-intensive and commodity-related sectors. The oil & gas sector is expected to be closely related to natural gas utilities; both sectors benchmark output prices to market prices for oil and natural gas, responding positively to price fluctuations; see Section 3.2.3.2. Section 3.2.3 also outlines other arguments regarding the similarity of the two sectors. The industrial sector has high energy consumption, similar to the electricity generation operation, which is negatively impacted by increasing fuel input prices. The chemical sector should be sensitive to carbon (or carbon equivalent) risk exposure; high-emitting electricity generators are negatively impacted by carbon price risk (Koch and Bassen, 2013). The telecommunication sector is a selected sector which is also dependent on transnational transmission networks. The restructuring of the telecommunication sector proxies for the impact of network liberalisation and induced competition. The banking sector was also subjected to EU sector liberalisation objectives (Gual, 1999). The bank, financial and insurance sectors are expected to positively respond to economy-wide conditions. Further, as the bank, financial and insurance sectors have no exposure to commodity price risk from operations, any sensitivity must be the result of either direct investment in commodities or indirectly through changes in valuation of (primarily energy) stock investment portfolios. The former point mimics the ability of energy utilities to speculate on the market price of commodities (Söderholm, 2001); see Section 3.3.5.2. The latter point relates to various reports in which bank and financial institutions have begun to acknowledge their exposure to commodity risk and stranded assets (Spedding et al., 2013, Carney, 2014). Finally, retail, technology and media are all expected to have no direct relationship with any commodity risk factors and hold little to no commodities.

4.2.4 Calculating the Size, Value and Momentum Premia

The following steps outline the creation of the global stock market risk factors from Fama and French (1993) and Carhart (1997). As argued in Section 3.2.2, additional stock market risk factors are expected to capture variation in return missed by the market factor and will be used in Equations (4.3) and (4.4). The factors include size, value and momentum premia. The former two are derived and examined in Fama and French (1993, 1995, 1997, 1998, 2006, 2012), and the momentum factor is derived and examined in Jegadeesh and Titman (1993), Carhart (1997) and Fama and French (2012). This chapter calculates the global stock market risk factors, which can explain returns across a variety of sectors by calculating the factors using a diversified universe of 600 European stocks. These global factors are used to perform the inter-sectoral comparisons (see Section 4.2.3.1). The following paragraphs outline how the SMB_t, HML_t and UMD_t factors for Equations (4.3) and (4.4) are calculated. Chapter 5 of this thesis adapts the research method to calculate local stock market risk factors for sector level analysis.

French (2015) provides access to a monthly time series for the three stock market risk factors for the European market. Unfortunately, monthly data are unsuitable as Chapters 5 and 6 of this thesis require daily data to perform analysis of time-varying risk factors and to implement the event study approach to examine the impact of regulations. French (2015) provides extensive guidelines regarding the replication of the three- and four-factor models using daily data. Therefore, the three stock market risk factors of size, value and momentum premia are manually calculated using daily data. Accordingly, it is important to ensure that these risk factors are comparable with French's. A brief comparison of the manually calculated risk factors against French's (2015) risk factors is provided in Appendix A. The overall conclusion of Appendix A is that risk factors calculated in the thesis accurately replicate French's and are suitable for use in analysis. Further, Appendix B also delineates the

600 firms into a 5 × 5 matrix to explore the effectiveness of the sorting method and for some descriptive statistics used later in the thesis.[47] The following paragraphs outline the construction of portfolios using these risk factors in line with Fama and French (1993).

To begin, six portfolios are formed on a simple sorting of firm size and book-to-market ratios. In June of each year t, from 1996 to 2013, all 600 stocks listed on the STOXX® 600 Europe Index are ranked on market capitalisation. Each year, the median market capitalisation is used to split the 600 firms into two groups: small and big firms. Of the available 8,863 annual observations, 4,453 (50.2%) are classified as big firms while 4,410 (49.8%) are classified as small firms. Despite having an approximately equal number of small and big firm observations, the combined value of small firms typically accounted for 5.84% of the total market value, across all firms and years. This finding is similar to Fama and French (1995), who found that small firms' combined value accounted for about 7.3% of total market value in 1991.

To form book-to-market portfolios, all 600 firms are ranked on their BE/ME ratios. The BE/ME ratio is calculated as the book value of common equity for the fiscal year $t-1$, scaled[48] by market capitalisation at the end of December in year $t-1$. The energy utilities are allocated to groups based on Fama and French's (1993, 1995, 1997, 1998, 2006, 2012) three break points: the top 30% (high-BE/ME), the middle 40% (mid-BE/ME) and the bottom 30% (low-BE/ME). In the recent literature, the three groups are often defined as value, neutral and growth stocks, respectively (Fama and French, 2006, Fama and French, 2012, French, 2015). The market capitalisation of value stocks is equal to or below the book value of equity, whereas growth stocks' market capitalisation is well above their book value of equity. Negative BE/ME firms are rare, but are excluded from break point calculations and BE/ME portfolio formation; the sample only contains two negative BE/ME observations. Of the eligible observations, 3,240 (36.6%) are high-BE/ME, 2,963 (33.4%) are mid-BE/ME and 2,660 (30.0%) are low-BE/ME. Manually calculating the thresholds is preferable to using independent thresholds; Fama and French (1993) find that independent size and BE/ME sorts result in the highest-BE/ME portfolios being tilted towards smallest stocks.

To ensure the accounting variables predate the returns they are used to explain, the accounting data for fiscal year $t-1$ are matched with the returns for July of year t to June of $t+1$ (Fama and French, 1992). This six month lag is due to Alford et al. (1994), who find

---

[47] While the statistics are not strictly useful for the AFFM, it provides confirmation that the data can be reliably sorted on firm size and (independently) BE/ME ratio, and will provide useful data for the interpretation of results in for Chapter 5, Section 5.4.2.1.

[48] Datastream provides the book value of equity in thousands and market value of equity in millions. Both were scaled appropriately to ensure BE/ME parity equalled 1.

that 19.8% of U.S. firms fail to submit their 10-K reports with the SEC within 90 days of fiscal year end. Conover et al. (2008) extend Alford et al. (1994) by including non-U.S. firms and find that European[49] firms are typically required to submit their reports six months after the fiscal year-end. European firms submit their reports within a range of 102 to 186 calendar days after fiscal year-end. The mean percentage of late reports is 24% across all European countries. This supports the assertion that, in the majority of cases, accounting information will be available within three to six months after the fiscal year-end. The portfolios are rebalanced at the end of June for $t + 1$.

To calculate the size and value premiums, the intersections of the two firm size groups and three book-to-market groups create six portfolios: S/L, S/M, S/H, B/L, B/M and B/H. Based on the classifications, the S/L portfolios contain firms which are classified as small and low-BE/ME, whereas the B/H portfolio contains firms which are classified as big and high-BE/ME. Daily value-weighted returns for the six portfolios are calculated from July of year t to June of year $t + 1$, with portfolio rebalancing occurring annually at the end of June of year $t + 1$.

The SMB (small minus big) risk factor (SMB_t) is constructed to represent size premium. The risk factor is calculated as the daily difference between the arithmetic average return of the three small portfolios (S/L, S/M and S/H) minus the arithmetic average return of the three big portfolios (B/L, B/M and B/H). The difference should be largely free of BE/ME influence and isolates the size effect (Fama and French, 1993). As small stocks are expected to generate higher returns than big stocks, the SMB_t represents a zero sum investment which is long on small stocks and short on big stocks. A positive (negative) SMB_t factor indicates that small stocks outperform (underperform) big stocks. A positive (negative) s_i coefficient indicates that the sector of interest behaves like small (big) stocks.

The HML (high minus low) risk factor (HML_t) is constructed to represent value premium. The risk factor is calculated as the daily difference between the arithmetic average of the two high-BE/ME portfolios (S/H and B/H) minus the arithmetic average of the two low-BE/ME portfolios (S/L and B/L). The HML_t factor should be largely free of the size effect, instead focusing on the impact of BE/ME (Fama and French, 1993). A pairwise correlation, see Table 4.4, confirms this proposition, showing a low correlation of 0.08 between the two risk factors. High-BE/ME stocks are expected to outperform low-BE/ME stocks, the HML_t represents a zero sum investment which is long on high-BE/ME stocks and

---

[49] European countries include Great Britain, Ireland, Netherland, Austria, Denmark, Finland, France, Germany, Italy, Spain and Sweden.

short on low-BE/ME stocks. A positive (negative) HML_t factor indicates that high-BE/ME stocks outperform (underperform) low-BE/ME stocks. A positive (negative) h_i coefficient indicates that the sector of interest behaves like high-BE/ME (low-BE/ME) stocks.

To study momentum, daily momentum portfolios are constructed from all 600 firms of the STOXX® 600 Europe Index following the method of Jegadeesh and Titman (1993), Carhart (1997), Fama and French (2012) and French (2015). The average excess return is calculated over the formation period from day $t-251$ to day $t-21$, and excludes the sort month. Excluding the sort month is the standard approach in momentum tests (Fama and French, 2012). Skipping the portfolio sort month avoids some effects of bid-ask spread, price pressure, lagged reactions and price reversals (De Bondt and Thaler, 1985, Jegadeesh and Titman, 1993). Based on French (2015), to be considered as an upper-momentum stock, the stock returns during the formation period and on $t-21$ must be positive; similarly, the stock returns during the formation period and return on $t-21$ must be negative for down-momentum stocks. The $t-21$ condition ensures that the upper and down momentums continue until the end of the formation period and reversal has not already begun. Based on Carhart (1997), Moskowitz and Grinblatt (1999) and French (2015), the break points are defined as the top 30% (upper momentum), the middle 40% (medium momentum) and the bottom 30% (down momentum). The value-weighted daily returns on the upper, medium, and down momentum portfolios are calculated.

The UMD (upper minus down) risk factor (UMD_t) is constructed to measure the momentum premium. The risk factor is calculated as the daily difference between the returns of the upper momentum and down momentum portfolios. Note, it is also common to refer to the portfolios as ‘winners’ and ‘losers’; see Section 3.2.2.4. Originally, Carhart (1997) takes an equal-weight average of firms with the highest 30% 11-month returns (lagged one month) minus the equal-weight average of firms with the lowest 30% eleven-month returns (lagged on month). Fama and French (1993) argue that a value-weighted portfolio minimises variance and captures the difference between the return behaviours of small and big stocks, or high- and low-BE/ME stocks, in a manner that relates to realistic investment opportunities. Moreover, the dependent variables, market factor, size and value premia, are also value-weighted measures. Therefore, this thesis adapts Carhart’s (1997) method and calculates value-weighted momentum portfolios. The portfolios are rebalanced daily. The UMD_t factor also represents a zero sum investment which is long on upper-momentum stocks and short on down-momentum stocks. It is worth noting that an active portfolio strategy such as momentum requires extremely high turnover (Moskowitz and Grinblatt, 1999). A positive (negative) UMD_t factor indicates that upper-momentum stocks outperform (underperform) down-momentum stocks. A positive (negative) m_i coefficient indicates that the sector of interest behaves like upper momentum (down momentum) stocks. Consideration was given to filtering low-priced stocks on an annual basis; however, Jegadeesh and Titman (2001) claim that the filtering of such stocks made no qualitative difference to their results. The following section presents the descriptive and econometric results of the chapter.

4.3 Results

This chapter asks four research questions, outlined in Section 4.1, namely: 1) do commodities impact returns in the European energy utility sector, 2) could stock-market risk factors better explain energy utilities' returns, 3) do these impacts reflect market-wide conditions or sector-specific relationships and 4) are these risk premia time-varying? As stated in Section 4.1, to address these research questions the chapter develops an augmented asset pricing model which includes stock market, term premium and commodity risk factors – the global AFFM.

The results section is structured as follows. Section 4.3.1 contains the descriptive results of the chapter. Within the descriptive results, Section 4.3.1.1 presents the return profiles of the sectors and risk factors through time, placing the data in context to illustrate the market and commodity crises that energy utilities and European stocks have experienced over the last two decades. Section 4.3.1.2 presents the summary statistics of the data. Section 4.3.1.3 briefly examines the pairwise correlations among energy utilities and other European sectors. Section 4.3.2 presents the empirical results of this chapter, addressing the four research questions.

4.3.1 Descriptive Results

4.3.1.1 Return profiles of sectors and risk factors

To illustrate asset pricing behaviour, Figure 4.1 plots the cumulative returns for the energy sector and the price indices of the remaining 10 European sectors. It is clear from Figure 4.1 (Plot A), that the European energy utility sector has experienced large changes in valuation through time, which may suggest some changes to the sector's relationship with underlying risk factors or impacts from regulatory changes. Between 1996 and 1998, the sector increases in value, which coincides with the first packages of energy liberalisation for the electricity (December 1996) and natural gas (July 1998) industries (see Section 2.2.1). The 2000 dot-com bubble has little to no impact on energy utilities. In contrast, the telecommunication (Plot D), technology (Plot H) and media (Plot I) sectors are severely impacted. Energy utilities generally decline in value until 2003, coinciding with the second packages of liberalisation (see Section 2.2.1). Although the value of energy utilities increases in price in the following years, it cannot reliably be attributed to the regulatory changes, as this also coincides with the build-up to the 2007 to 2009 GFC. This increase in price is observed across many sectors. Post-GFC, the majority of European sectors decline in value. The energy utility sector suffers a prolonged depression of stock prices post-GFC. This time period encompasses the EUC of 2010 to 2011, the third packages of liberalisation (see Section 2.2.1) and is also consistent with the loss in market capitalisation and the poor performance of energy utilities reported by The Economist (2013b) – argued to be the result of renewables. Daily return profiles, Figure 4.2 provide a clearer picture of the magnitude of returns across all 11 sectors. The dot-com crisis continues to be limited to the telecommunication, technology and media sectors; in contrast, the GFC is observed across most sector portfolios. The heterogeneity of sector portfolios gives confidence in identifying sector-specific relationships.

Having addressed the return profiles of the sectors, Figure 4.3 and Figure 4.4 present the data and daily returns regarding the risk factors used in analysis. The sources of data were outlined in Section 4.2.3, while the calculation of the stock market risk factors (size, value and momentum premia) was outlined in Section 4.2.4. For Figure 4.3, the price index of the market factor (Plot D) clearly capture the impacts of the dot-com and GFC crises. While energy utilities appear to fluctuate with the market factor (with lower magnitude), the price index of the market factor recovers post-GFC, while the value of energy utilities remains low. If there is to be any shift in systematic risk, the post-GFC time period is a likely candidate; again, this also coincides with the third packages of liberalisation (see Section 2.2.1).

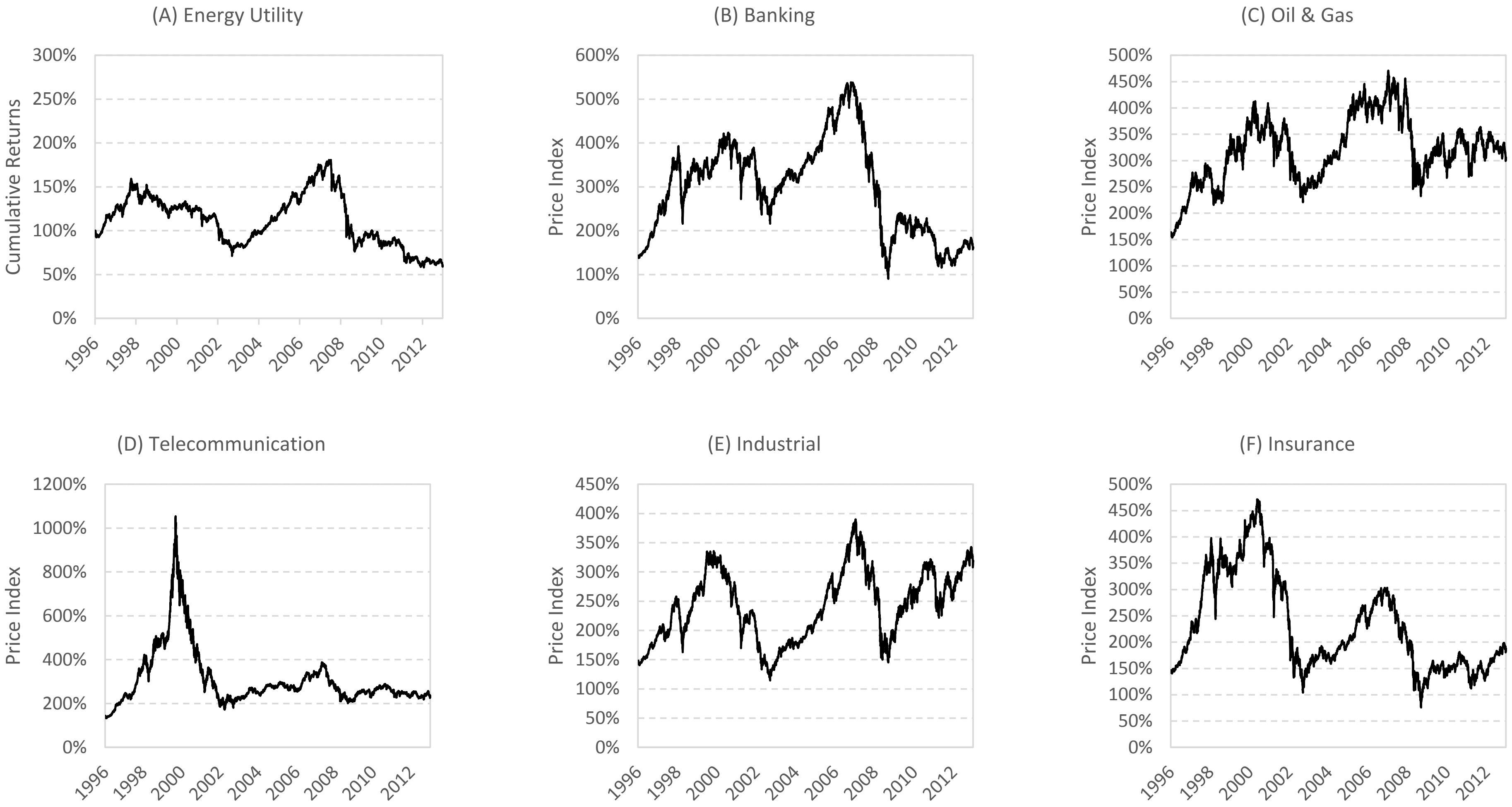


FIGURE 4.1: PRICE INDICES AND CUMULATIVE RETURNS FOR THE 11 EUROPEAN SECTOR PORTFOLIOS

This figure presents the cumulative returns and price indices of the 11 sector portfolios analysed in this chapter. The cumulative returns are calculated for the energy utility sector while the price indices are presented for the remaining 10 sector portfolios. Due to the differential impact of the dot-com bubble and the GFC, which resulted in largechanges in sector valuation, the scales are independent for each plot.

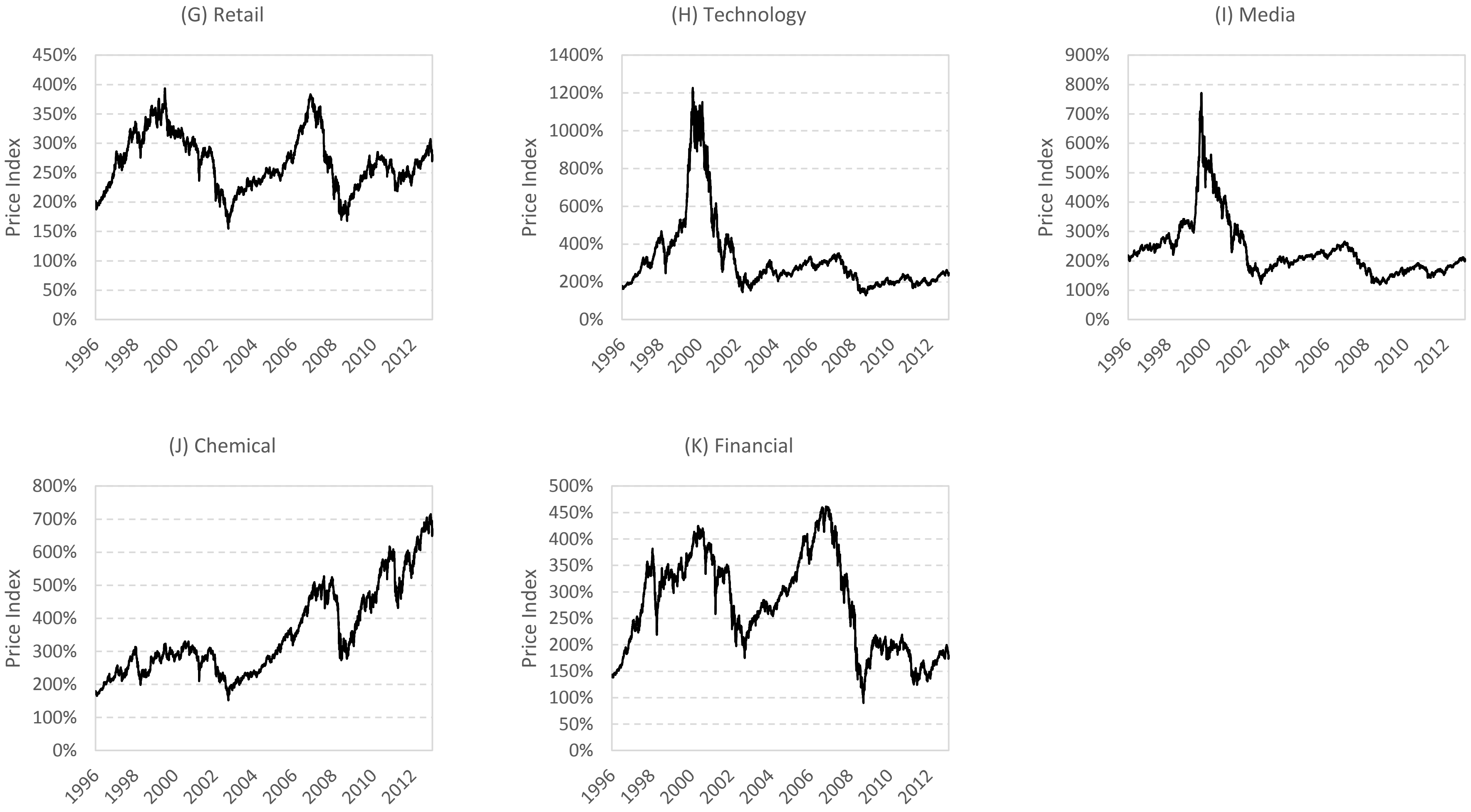


FIGURE 4.1 (CONTINUED)

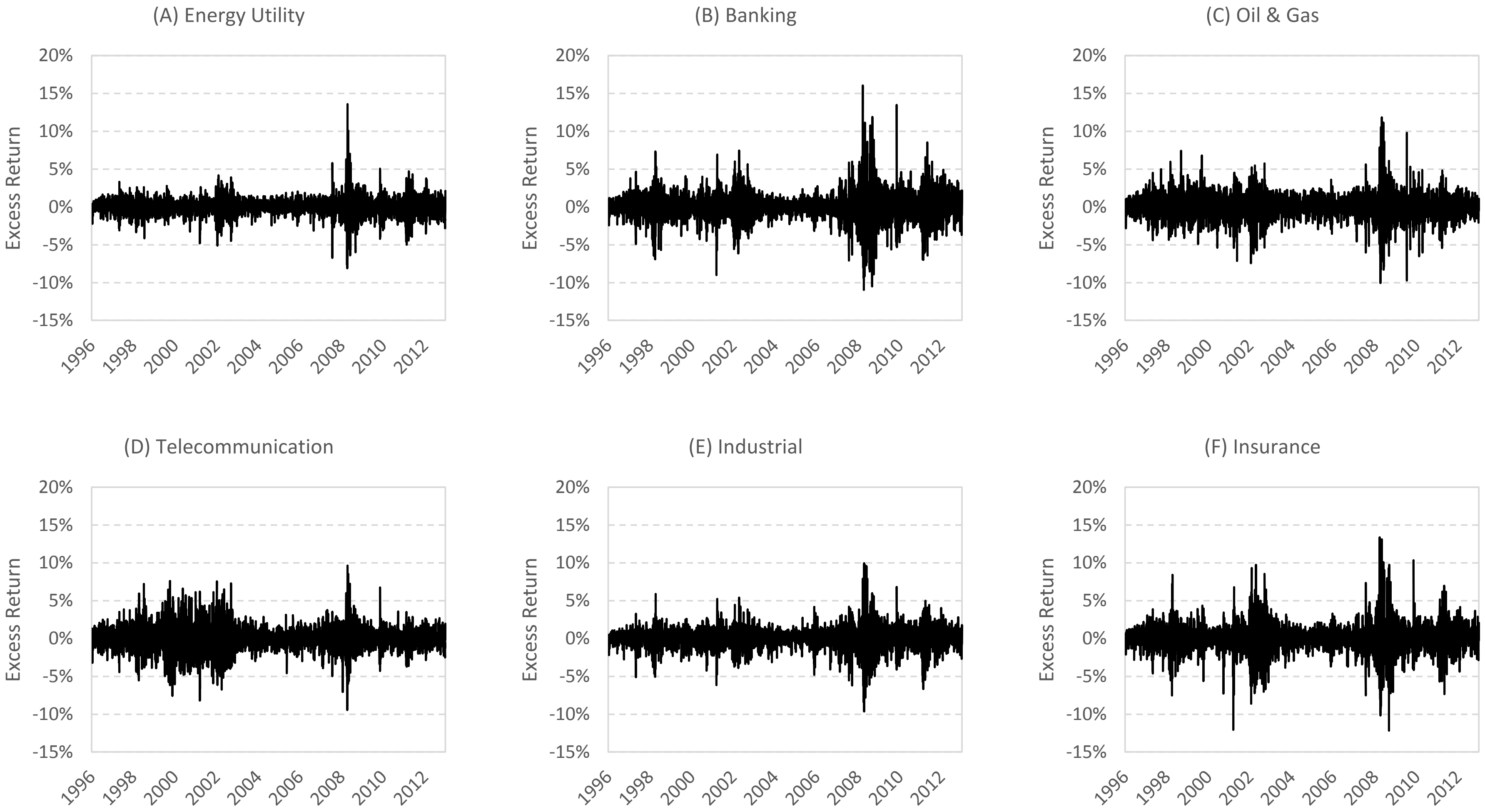


FIGURE 4.2: DAILY RETURNS FOR THE 11 EUROPEAN SECTOR PORTFOLIOS

This figure illustrates the excess returns for the 11 sector portfolios. Excess returns are calculated as the first-log difference of price, subtracting the one month UK treasury bill.

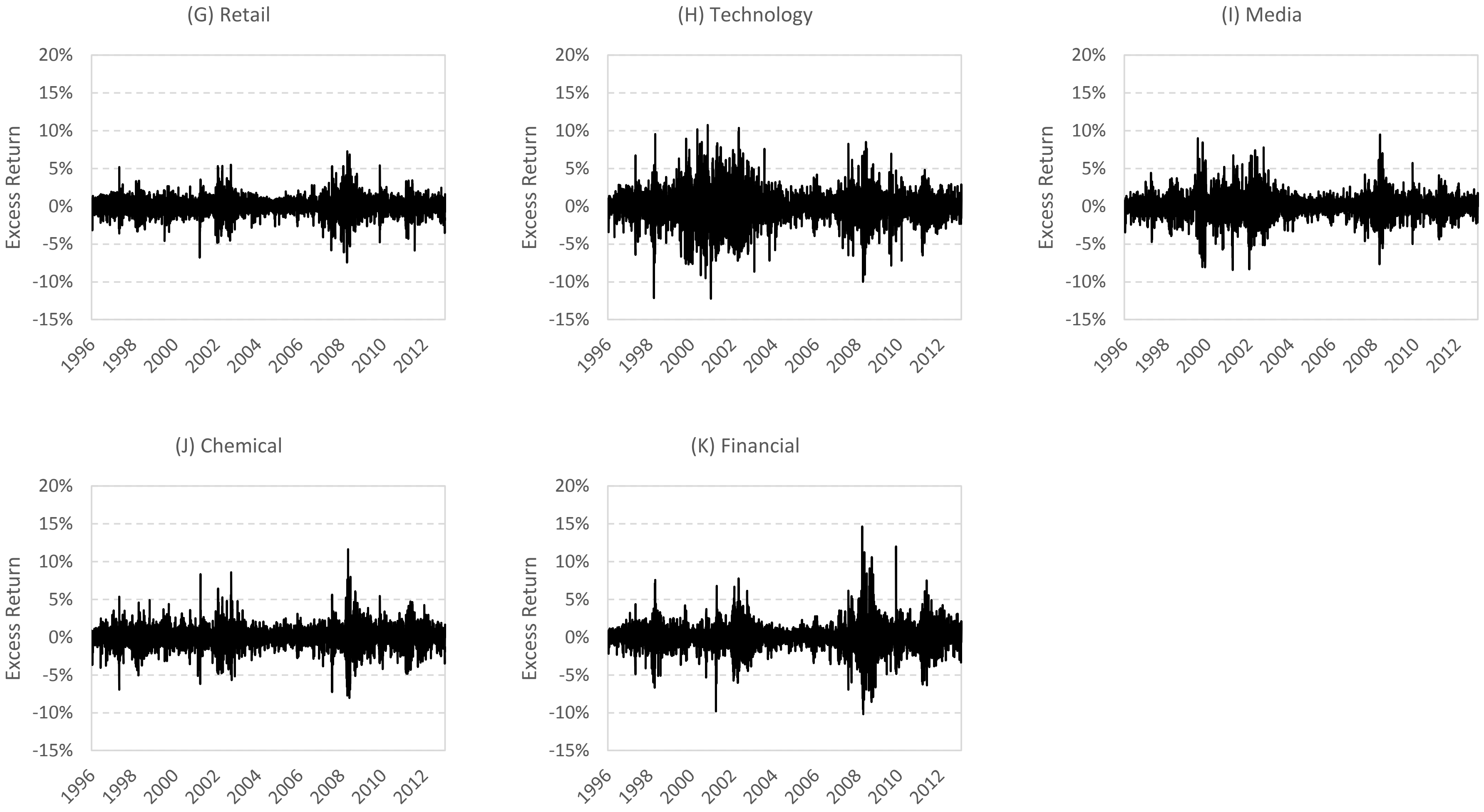


FIGURE 4.2 (CONTINUED)

For Figure 4.3, the increasing SMB factor (Plot A) shows that small European stocks outperform big European stocks, consistent with the expectations of Banz (1981), Chan et al. (1985) and Fama and French (1993) in Section 3.2.2.1. The HML factor (Plot B) shows that high-BE/ME European stocks outperform low-BE/ME European stocks, consistent with the results of Rosenberg et al. (1985), Chan and Chen (1991) and Fama and French (1993) in Section 3.2.2.2. The HML factor appears to reverse post-GFC, where low-BE/ME European stocks outperform high-BE/ME stocks. This may indicate that distressed stocks performed poorly post-GFC. Overall, the cumulative returns of the HML factor is lower than the SMB and UMD factors, suggesting the value premium may be small for European stocks. Finally, the increasing UMD factor (Plot C) shows that upper momentum European stocks outperform down momentum European stocks for the majority of the time series, consistent with the expectations of Carhart (1997) and Jegadeesh and Titman (1993; 2001). Post-GFC, the UMD factor shows that all stocks suffer a decline in value, but the momentum factor soon recovers.

Regarding term premium (Plot E), the daily yields on the three- and one-month treasury bills declined post-GFC, consistent with economic downturns (Sadorsky, 2001). As mentioned in Section 4.1, this chapter improves on El-Sharif et al. (2005) and Oberndorfer (2009a) by including this change in term premium. Also noted in Section 4.1, commodities have experienced record high prices over the last two decades. In particular, crude oil prices (Plot F) experienced a five-fold increase between 1996 and 2013, while the coal index (Plot G) mostly followed a similar patter to oil prices. Natural gas prices (Plot H) have experienced rapid changes across time, increasing from €0.20 per therm in 1996 to over €1.60 per therm in 2006; shortly after, natural gas prices decline. The carbon price (Plot I) is highly volatile. In late 2007, carbon prices fall to effectively zero (€0.01 per EUA) due to the expiration of Phase I EUAs. From March 2008, Phase II EUAs were priced at approximately €20 per EUA but rapidly decline thereafter. Regarding Figure 4.4, the market factor and stock market risk factors are generally more volatile surrounding the dot-com bubble and GFC, the term premium shifts post-2008 and oil, coal and natural gas returns are volatile throughout time. Carbon price returns show high volatility at the end of Phase I (2007), which is likely due to prices being close to zero. During Phase II, the returns are of a smaller magnitude.

(A) SMB Factor

(B) HML Factor

(C) UMD Factor

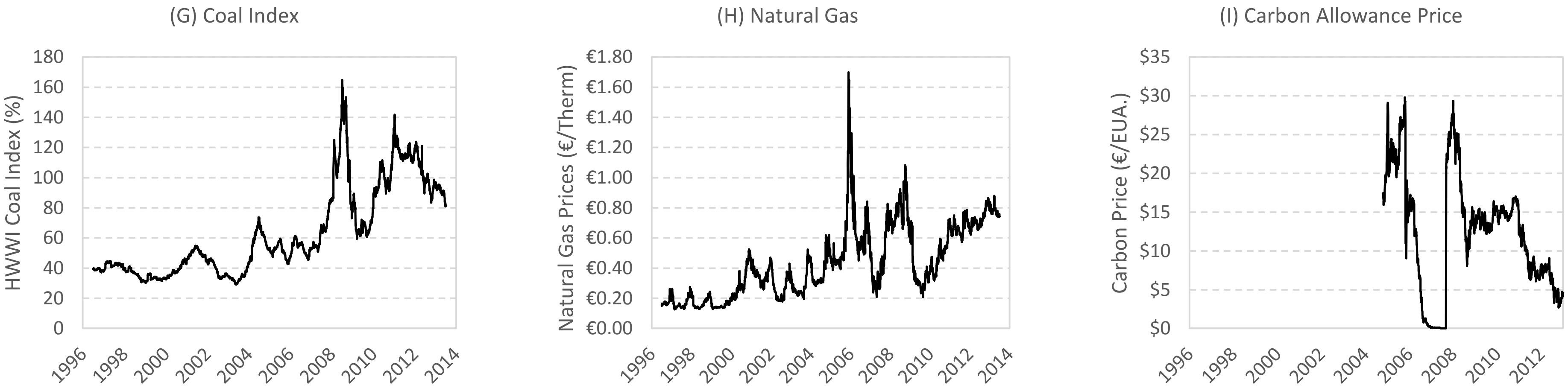
(D) Market Factor

(E) Treasury Bills

(F) Crude Oil Prices

Figure 4.3: Prices, Price Indices and Cumulative returns for the Risk Factors

This figure illustrates the cumulative returns, the price indices, market prices or the daily yield for the nine risk factors used as independent variables. The cumulative returns are presented for the SMB factor (Plot A), the HML factor (Plot B) and the UMD factor (Plot C). The price index is shown for the market factor (Plot D) and the coal index (Plot G). The daily yields on the three and 1 month UK treasury bills are shown in Plot E. The figure also shows the market prices for crude oil (Plot F), natural gas (Plot H) and carbon allowances (Plot I).



(G) Coal Index

(H) Natural Gas

(I) Carbon Allowance Price

Figure 4.3 (continued)

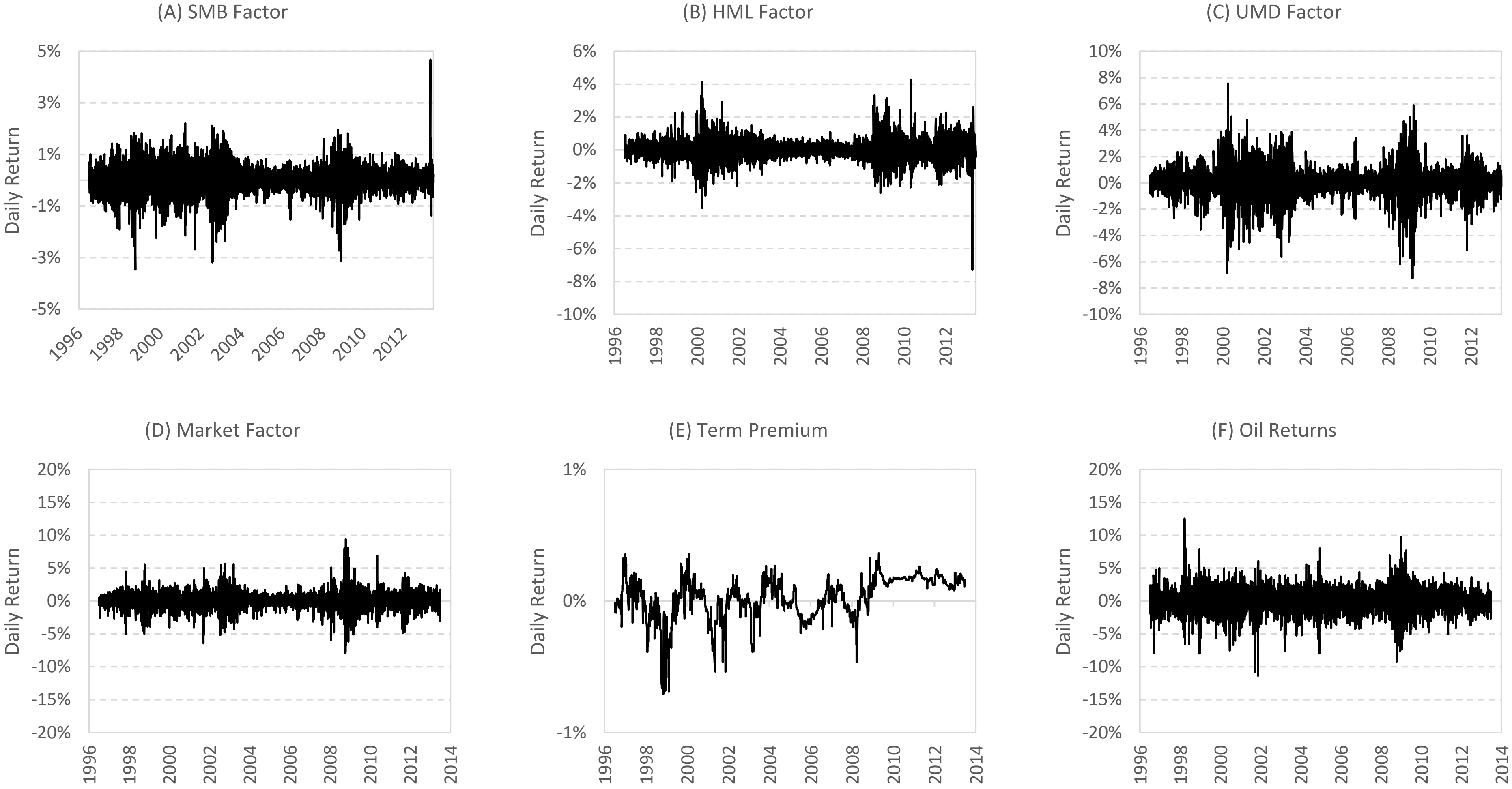


FIGURE 4.4: DAILY RETURN PROFILES FOR THE RISK FACTORS

This figure illustrates the daily returns for the nine risk factors. The calculations of the SMB, HML and UMD risk factors (Plots A to C) are outlined in Section 4.2.4. The daily return on the market factor (Plot D), oil prices (Plot E), coal prices (Plot G), natural gas prices (Plot H) and carbon prices (Plot I) are calculated as the first-log difference of the price index or market price. Term premium is calculated as the difference between the daily yields of the three- and one-month UK treasury bills.

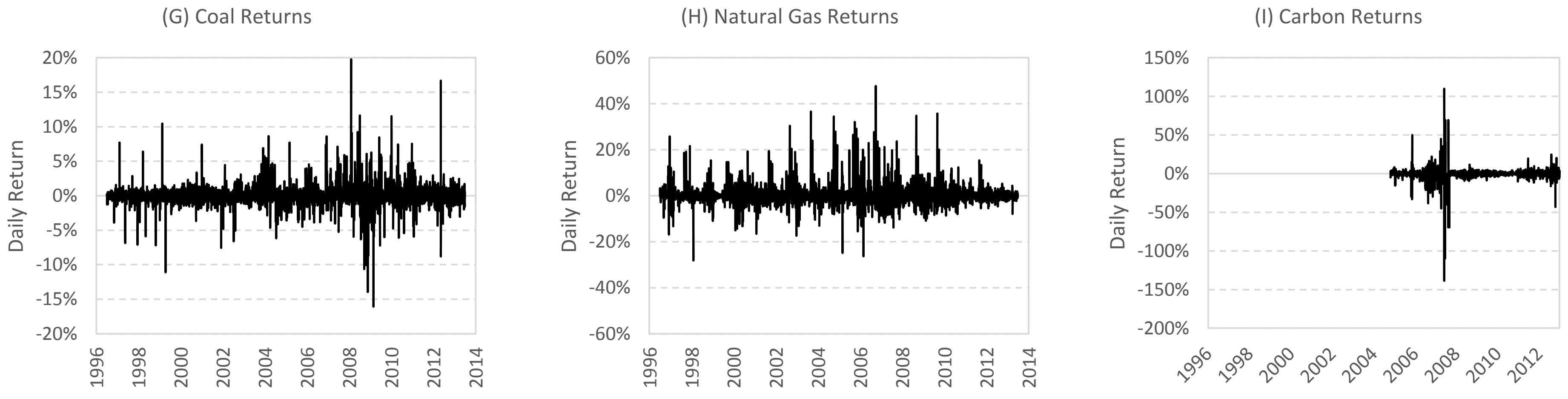


FIGURE 4.4 (CONTINUED)

The descriptive statistics have shown that the macroeconomic and stock market risk factors have undergone dramatic changes over the last two decades. Importantly, the results suggest the existence of a size, value and momentum premia in European stock returns. Also, as mentioned in Section 4.1, European stocks have been impacted by a variety of stock and commodity crises. Clearly, there are many macroeconomic variables which must be controlled for to reliably explore the impact of regulatory changes in Chapter 6.

4.3.1.2 Summary statistics

Table 4.2 reports the summary statistics for the daily returns of the 11 sectors and nine risk factors. Mean daily returns are also annualised for comparisons against relevant literature. The t-statistics for the mean shows that the average daily excess return, across all 11 sectors, is not statistically different from zero. Mean daily excess returns range between -0.012% and 0.020%; energy utilities achieve a mean daily excess return of -0.005%. For the risk factors, the mean daily excess return on the STOXX® 600 Europe index is 0.004%, while term premium, oil, coal, gas and carbon achieve daily returns of 0.026%, 0.038%, 0.016%, 0.042% and -0.423%, respectively. The mean daily return for carbon is statistically significant at $p = 0.008$ and term premium is significant at $p \leq$ 0.001; oil, coal and natural gas were insignificant.

The lack of significant daily means for the energy utility sector and commodities is similar to Oberndorfer (2009a). While Oberndorfer (2009a) and El-Sharif et al. (2005) find a lack of significance in term premium, a positive and significant term premium coefficient is congruent with Sadorsky (2001). The lack of consistency across papers, especially Oberndorfer (2009a), who performs a similar analysis on European utilities, suggests a lack of inter-temporal consistency. The insignificant term premium found in Oberndorfer (2009a) and El-Sharif et al. (2005) may be due to the time period analysed. As shown in Figure 4.3, the yield on treasury bills decline post-GFC, while Figure 4.4 shows that term premium, the spread between yields, increases post-GFC. For the stock market risk factors, the SMB, HML and UMD factors achieve daily returns of 0.025%, 0.002% and 0.031%, respectively. The SMB portfolio is significant at $p = 0.002$, while UMD is significant at $p = 0.071$. The daily means are congruent with expectations from Fama and French (1993): small firms outperform big firms. High-BE/ME firms outperform low-BE/ME firms but the HML factor over the entire series is not significantly different from zero, likely due to the reversal post-GFC. Upper momentum firms outperform down momentum firms using market level data, congruent with Jegadeesh and Titman (1993) and Carhart (1997).

TABLE 4.2: SUMMARY STATISTIC FOR THE EUROPEAN SECTORS AND RISK FACTORS

This table presents summary statistics for the 11 sectors and nine risk factors, including: number of daily observations (N), mean daily return, the t-statistic of the mean, standard deviation of mean daily return, annualised mean daily return, minimum and maximum observations, skewness and kurtosis. The t-mean statistic is the ratio of the mean to its standard error. The 11 value-weighted sector portfolios include: energy utility ($\boldsymbol{R_{util,t}}$), bank ($\boldsymbol{R_{banks,t}}$), oil & gas ($\boldsymbol{R_{O\&G,t}}$), telecommunication ($\boldsymbol{R_{tele,t}}$), industrial ($\boldsymbol{R_{ind,t}}$), insurance ($\boldsymbol{R_{ins,t}}$), retail ($\boldsymbol{R_{ret,t}}$), technology ($\boldsymbol{R_{tech,t}}$), media ($\boldsymbol{R_{media,t}}$), chemical ($\boldsymbol{R_{chem,t}}$), and financial ($\boldsymbol{R_{fin,t}}$). The nine risk factors include: market factor ($\boldsymbol{R_{m,t}}$), size premium (SMB_t), value premium (HML_t), momentum premium (UMD_t) term premium ($\boldsymbol{R_{tp,t}}$), oil price risk ($R_{o,t}$), coal price risk ($R_{c,t}$), natural gas price risk ($R_{g,t}$), and carbon price risk ($R_{co2,t}$). A ****, ***, ** or * denotes significance at 0.1%, 1%, 5% or 10%, respectively.

	$\boldsymbol{R_{util,t}}$	$\boldsymbol{R_{banks,t}}$	$\boldsymbol{R_{O\&G,t}}$	$\boldsymbol{R_{tele,t}}$	$\boldsymbol{R_{ind,t}}$	$\boldsymbol{R_{ins,t}}$	$\boldsymbol{R_{ret,t}}$	$\boldsymbol{R_{tech,t}}$	$\boldsymbol{R_{media,t}}$	$\boldsymbol{R_{chem,t}}$
N	4435	4435	4435	4435	4435	4435	4435	4435	4435	4435
Mean Daily	-0.0051%	-0.0073%	0.0039%	0.0007%	0.0069%	-0.0047%	-0.0031%	-0.0029%	-0.0117%	0.0195%
***t*-Mean**	(-0.30)	(-0.28)	(0.17)	(0.03)	(0.34)	(-0.17)	(-0.18)	(-0.09)	(-0.52)	(0.94)
Std. Dev. Daily	1.11%	1.73%	1.55%	1.58%	1.35%	1.80%	1.17%	2.05%	1.49%	1.39%
Mean Annualized	-1.31%	-1.88%	1.02%	0.18%	1.80%	-1.21%	-0.80%	-0.76%	-2.99%	5.21%
Min	-8.10%	-10.98%	-10.05%	-9.45%	-9.62%	-12.18%	-7.44%	-12.23%	-8.44%	-8.05%
Max	13.60%	16.08%	11.85%	9.65%	9.97%	13.40%	7.28%	10.75%	9.51%	11.61%
Skew	0.09	0.14	-0.09	0.06	-0.19	0.04	-0.21	-0.13	-0.05	-0.09
Kurt	14.80	10.62	8.84	6.27	8.75	9.71	7.08	6.36	7.39	8.21

	$\boldsymbol{R_{fin,t}}$	$\boldsymbol{R_{m,t}}$	SMB_t	HML_t	UMD_t	$\boldsymbol{R_{tp,t}}$	$R_{o,t}$	$R_{c,t}$	$R_{g,t}$	$R_{co2,t}$[A]
N	4435	4435	4436	4436	4436	4435	4435	4435	4435	2135
Mean	-0.0052%	0.0036%	0.0252%	0.0017%	0.0312%	0.0262%	0.0383%	0.0158%	0.0424%	-0.4233%
***t*-Mean**	(-0.21)	(0.19)	(3.06)***	(0.18)	(1.81)*	(11.10)****	(1.43)	(0.78)	(0.76)	(-2.64)***
Std. Dev. Daily	1.65%	1.26%	0.55%	0.62%	1.15%	0.16%	1.78%	1.36%	3.73%	7.42%
Mean Annualized	-1.35%	0.95%	6.78%	0.43%	8.45%	7.04%	10.46%	4.20%	11.66%	-66.81%
Min	-10.19%	-7.94%	-3.47%	-7.29%	-7.27%	-0.71%	-11.35%	-16.08%	-28.13%	-138.63%
Max	14.65%	9.40%	4.68%	4.29%	7.55%	0.36%	12.56%	19.78%	47.77%	109.86%
Skew	0.09	-0.17	-0.29	-0.07	-0.48	-1.06	-0.27	0.80	2.57	-3.14
Kurt	10.08	7.96	7.21	11.19	7.72	4.74	6.17	38.75	28.85	121.76

[A] As mentioned, the statistics for the carbon series hereon in are based on the data which excludes the 764% price increase of March 2008. For comparison, the unadjusted summary statistics were: N = 2135, Mean = -0.0653%, t-mean = (-0.17), Std. Dev. = 18.14%, Min = -138.63%, Max = 764.40%, Skew = 34.85, Kurt = 1482.02. The unusual observation biased most analyses.

Augmented Dickey-Fuller (1979) (ADF) unit root tests are implemented to examine the data generating processes of the variables used in analysis. The ADF tests are implemented to test the assumption that the data-generating process of the dependent and independent variables are integrated to the same order, ensuring there can be a linear relationship between the variables. The results of the ADF test, shown in Table 4.3, confirm that the time series for all 11 sectors and nine risk factors are integrated to order zero, $I(0)$ and stationary.

TABLE 4.3: AUGMENTED DICKEY-FULLER TESTS

This table presents the results of the ADF test for unit roots. The null hypothesis is that the variable contains a unit root, against the alternative of no unit root (stationarity). A ***, ** or * denotes 1%, 5% or 10% significance, respectively. The ADF test does not report significance greater than 1%.

Variable	ADF Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value	Sig.
$\boldsymbol{R_{util,t}}$	-66.04	-3.43	-2.86	-2.57	***
$\boldsymbol{R_{banks,t}}$	-62.61	-3.43	-2.86	-2.57	***
$\boldsymbol{R_{O\&G,t}}$	-67.76	-3.43	-2.86	-2.57	***
$\boldsymbol{R_{tele,t}}$	-65.21	-3.43	-2.86	-2.57	***
$\boldsymbol{R_{ind,t}}$	-62.87	-3.43	-2.86	-2.57	***
$\boldsymbol{R_{ins,t}}$	-63.56	-3.43	-2.86	-2.57	***
$\boldsymbol{R_{ret,t}}$	-67.76	-3.43	-2.86	-2.57	***
$\boldsymbol{R_{tech,t}}$	-64.73	-3.43	-2.86	-2.57	***
$\boldsymbol{R_{media,t}}$	-61.65	-3.43	-2.86	-2.57	***
$\boldsymbol{R_{chem,t}}$	-64.86	-3.43	-2.86	-2.57	***
$\boldsymbol{R_{fin,t}}$	-62.94	-3.43	-2.86	-2.57	***
$\boldsymbol{R_{m,t}}$	-66.21	-3.43	-2.86	-2.57	***
SMB_t	-68.30	-3.43	-2.86	-2.57	***
HML_t	-60.00	-3.43	-2.86	-2.57	***
UMD_t	-57.56	-3.43	-2.86	-2.57	***
$\boldsymbol{R_{tp,t}}$	-55.53	-3.43	-2.86	-2.57	***
$R_{o,t}$	-55.95	-3.43	-2.86	-2.57	***
$R_{c,t}$	-66.76	-3.43	-2.86	-2.57	***
$R_{g,t}$	-63.62	-3.43	-2.86	-2.57	***
$R_{co2,t}$	-47.63	-3.43	-2.86	-2.57	***

Where ***, ** and * denotes 1%, 5% and 10% significance, respectively. The ADF test in stat does not test significance beyond 1%.

The pairwise correlation matrix of daily returns, for all 11 sectors and nine risk factors, are shown in Table 4.4. With respect to the risk factors, the market factor shows positive correlation among all 11 sectors with varying magnitudes. This result is expected, as all portfolios must share some form of systematic risk; in addition, many of the sectors represent around 5% of the market factor's constituents (shown in Table 4.1). The stock market risk factors have low correlations with each other, congruent with Fama and French (1993). Regarding the SMB and HML factors, both factors show statistically significant coefficients with sector portfolios. In the absence of competition from the market factor, the SMB and HML are able to capture *some* variation in stock returns (Fama and French, 1993). However, drawing inference at this stage can be misleading, as Fama and French (1993, 1997) show that SMB and HML do not suffice in accurately explaining average returns in isolation, leaving common variation in stock returns which is better explained by the market factor. Both risk factors are designed to be used in conjunction with the market factor, addressing the CAPM's low explanatory power for small and high-BE/ME stocks. This rule is also applied to the UMD (momentum) factor. Further, analysis in Section 4.3.2.1 will show that the pairwise correlations produce biased correlation estimates for the stock market risk factors.

Regarding term premium, the results are insignificant across all sectors and risk factors. Oil has a positive correlation with the oil & gas sector and term premium. Coal has a positive correlation with four sectors, the market factor and a negative correlation with the HML factor. Interestingly, the sectors positively correlated with coal are typically technology and service industries. It is possible that coal may proxy for an unobserved variable relating to energy demand, or is capturing returns better explained by stock market factors; this proposition is addressed in Section 4.3.2.1. Natural gas has a positive correlation with the oil & gas, industrial, insurance and chemical sectors. Carbon risk is positively correlated with all 11 sectors the economy, the market factor, the HML factor and natural gas. Carbon has negative correlations with coal and the SMB and UMD factors.

Across all significant commodities, the magnitudes of the correlations are all small, ranging from -0.057 to 0.090. Therefore, the economic impact of commodities on a sector's returns is likely to be small regardless of statistical significance, and statistical significance may disappear when included in multivariate regressions with more relevant stock market risk factors. This behaviour is well documented in Fama and French (1993), who demonstrate that bond-market risk factors are significant determinants of stock returns when examined in isolation; the significance is nullified when stock market risk factors are included as the return on bond factors is typically small in comparison with stock factors.

4.3.1.3 Is the energy utility sector distinct to the oil & gas sector?

As discussed in the introduction to the thesis (Section 1.1) and the literature review (Section 3.2.3), there is often the assumption that the risk exposure of the oil & gas sector holds for the energy utility sector, where risk factors which affect oil & gas firms are assumed to also impact energy utilities. This assumption can lead to incorrect inferences in equilibrium asset pricing for energy utilities, incorrect calculation of the cost of capital and an inability to accurately identify firm-specific risk.

TABLE 4.4: PAIRWISE CORRELATIONS

This table presents pairwise correlations between the 11 portfolios and nine risk factors. A ****, ***, ** or * denotes significance at 0.1%, 1%, 5% or 10%, respectively.

	Dependent Variables											Independent Variables								
	$\boldsymbol{R_{util,t}}$	$\boldsymbol{R_{banks,t}}$	$\boldsymbol{R_{O\&G,t}}$	$\boldsymbol{R_{tele,t}}$	$\boldsymbol{R_{ind,t}}$	$\boldsymbol{R_{ins,t}}$	$\boldsymbol{R_{ret,t}}$	$\boldsymbol{R_{tech,t}}$	$\boldsymbol{R_{media,t}}$	$\boldsymbol{R_{chem,t}}$	$\boldsymbol{R_{fin,t}}$	$\boldsymbol{R_{m,t}}$	SMB_t	HML_t	UMD_t	$\boldsymbol{R_{tp,t}}$	$R_{o,t}$	$R_{c,t}$	$R_{g,t}$	$R_{co2,t}$
$\boldsymbol{R_{util,t}}$	1.000																			
$\boldsymbol{R_{banks,t}}$	0.725 ****	1.000																		
$\boldsymbol{R_{O\&G,t}}$	0.727 ****	0.640 ****	1.000																	
$\boldsymbol{R_{tele,t}}$	0.618 ****	0.655 ****	0.507 ****	1.000																
$\boldsymbol{R_{ind,t}}$	0.739 ****	0.841 ****	0.679 ****	0.680 ****	1.000															
$\boldsymbol{R_{ins,t}}$	0.748 ****	0.895 ****	0.651 ****	0.665 ****	0.833 ****	1.000														
$\boldsymbol{R_{ret,t}}$	0.689 ****	0.738 ****	0.610 ****	0.657 ****	0.782 ****	0.749 ****	1.000													
$\boldsymbol{R_{tech,t}}$	0.559 ****	0.661 ****	0.506 ****	0.747 ****	0.744 ****	0.677 ****	0.638 ****	1.000												
$\boldsymbol{R_{media,t}}$	0.613 ****	0.690 ****	0.540 ****	0.757 ****	0.770 ****	0.709 ****	0.704 ****	0.764 ****	1.000											
$\boldsymbol{R_{chem,t}}$	0.725 ****	0.739 ****	0.677 ****	0.580 ****	0.817 ****	0.769 ****	0.693 ****	0.622 ****	0.623 ****	1.000										
$\boldsymbol{R_{fin,t}}$	0.753 ****	0.988 ****	0.665 ****	0.680 ****	0.868 ****	0.948 ****	0.768 ****	0.689 ****	0.720 ****	0.771 ****	1.000									
$\boldsymbol{R_{m,t}}$	0.818 ****	0.899 ****	0.760 ****	0.808 ****	0.923 ****	0.900 ****	0.841 ****	0.807 ****	0.830 ****	0.830 ****	0.928 ****	1.000								
SMB_t	-0.439 ****	-0.408 ****	-0.427 ****	-0.526 ****	-0.333 ****	-0.440 ****	-0.362 ****	-0.499 ****	-0.349 ****	-0.397 ****	-0.424 ****	-0.499 ****	1.000							
HML_t	0.211 ****	0.357 ****	0.163 ****	-0.058 ****	0.185 ****	0.279 ****	0.111 ****	-0.146 ****	-0.054 ****	0.203 ****	0.332 ****	0.128 ****	0.086 ****	1.000						
UMD_t	-0.192 ****	-0.384 ****	-0.177 ****	-0.169 ****	-0.256 ****	-0.375 ****	-0.199 ****	-0.205 ****	-0.183 ****	-0.237 ****	-0.383 ****	-0.248 ****	0.126 ****	-0.315 ****	1.000					
$\boldsymbol{R_{tp,t}}$	-0.007	-0.018	-0.007	-0.006	-0.007	-0.005	-0.006	-0.010	-0.005	-0.005	-0.014	-0.009	0.003	0.003	0.015	1.000				
$R_{o,t}$	0.020	-0.009	0.085 ****	-0.014	0.006	-0.007	-0.024	-0.004	-0.002	0.004	-0.007	0.004	0.003	-0.006	0.006	0.025 *	1.000			
$R_{c,t}$	-0.023	0.003	0.024	0.031 **	0.010	-0.006	0.033 **	0.050 ****	0.047 ***	-0.002	0.002	0.027 *	-0.023	-0.057 ****	0.019	0.007	0.012	1.000		
$R_{g,t}$	0.024	0.021	0.036 **	0.001	0.029 *	0.027 *	0.020	0.008	0.015	0.028 *	0.023	0.021	0.013	0.016	-0.006	0.004	0.005	-0.007	1.000	
$R_{co2,t}$	0.078 ****	0.077 ****	0.090 ****	0.054 **	0.079 ****	0.082 ****	0.082 ****	0.080 ****	0.066 ***	0.070 ***	0.081 ****	0.082 ****	-0.039 *	0.048 **	-0.055 **	0.010	-0.029	-0.052 **	0.061 ***	1.000

Note: Correlations between carbon and other variables are estimated over 2,135 observations to reflect the shorter time series.

The pairwise correlations in Table 4.4 show that all 11 sectors have positive and significant correlations with one another, varying from 0.506 to 0.988. For interpretation, we define sector correlations greater than 0.70 to represent high correlations. The threshold is chosen to remain consistent with the 70th percentile used in the stock market factor constructions in Section 4.2.4. A more stringent threshold could be implemented but may limit discussion; ultimately, the choice is arbitrary. Based on high correlations between sector portfolios, a node network between sectors is shown in Figure 4.5.

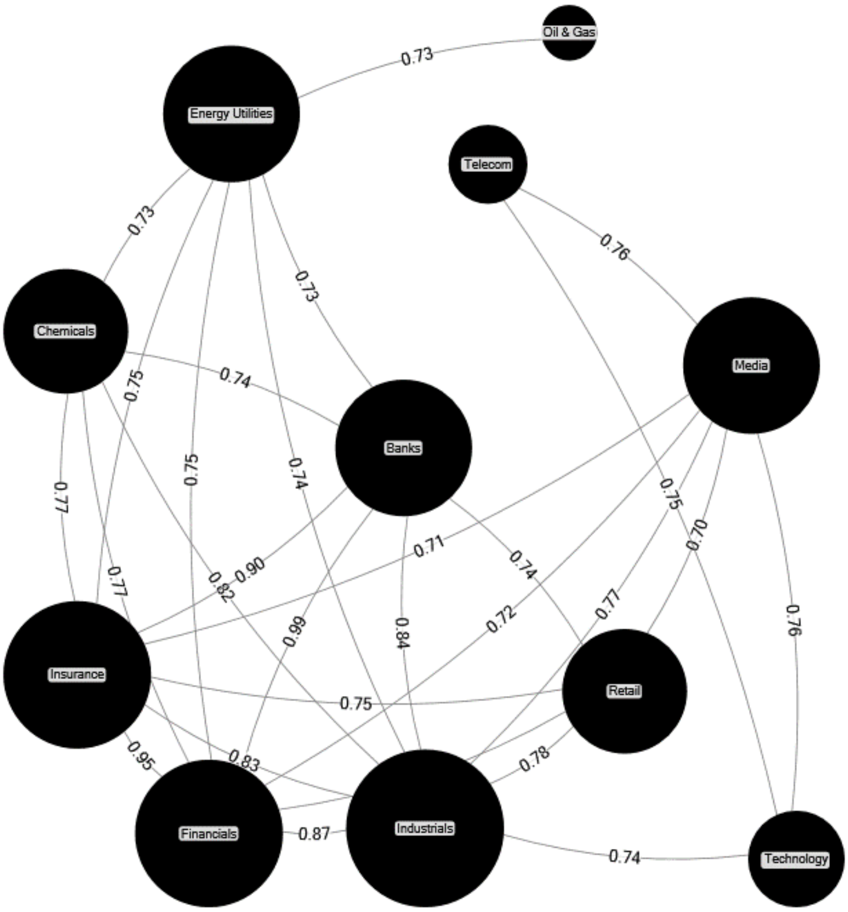


FIGURE 4.5: NODE NETWORK OF EUROPEAN SECTOR RETURN CORRELATIONS

This figure shows a node network of European sectors' daily return correlations. The nodes represent each of the 11 sectors' returns. The size of the node indicates the number of pairwise correlations with other sectors, as represented by the edges (curved lines). Larger node size indicates more edges. The node locations are estimated using the Fruchterman-Reingold force-directed graph drawing algorithm to minimise cross edges. The edge values are extracted from Table 4.4 to represent the degree of correlation between sector returns. The length of edges provide no additional information.

The node network shows that many of the European sectors are inter-related and show high correlation with one another. The returns of the energy utility sector have a high correlation with six European sectors: insurance (0.75), financial (0.75), industrial (0.74), bank (0.73), chemicals (0.73) and oil & gas (0.73). The energy utility sector must share elements of risk exposure with the aforementioned sectors. In contrast, the oil & gas sector only has one high correlation – the energy utility sector (0.73). Therefore, it is incorrect to assume that the oil & gas sector is representative of the energy utility sector, as other European sectors have equal or greater correlations with utilities.

The most probable connection between the oil & gas and energy utility sectors is through commodity prices, specifically oil and natural gas. Table 4.4 shows that oil and natural gas returns have significant pairwise correlations with the oil & gas sector, while both commodities marginally miss significance at the 10% level for the energy utility sector, with $p = 0.1879$ and $p = 0.1118$, respectively. Inter-temporal analysis may show temporary significance through time, similar to El-Sharif et al. (2005). Oberndorfer (2009a) argues that the value of energy utilities and oil & gas firms may be benchmarked against commodity prices, explaining the significant relationship despite the fact that oil is rarely used in energy production.

4.3.2 Econometric Results

Table 4.5 presents the results of the four asset pricing models: the CAPM (Equation 4.1), augmented-CAPM (Equation 4.2), the four-factor (Equation 4.3) and the global AFFM (Equation 4.4) introduced in this chapter; as discussed in Section 4.2.1. The time period covered is 01 July 1996 to 28 June 2013 (4,435 daily observations). Due to the relatively short time series, carbon prices are not included in the full-period multifactor regression, but are included in the inter-temporal analysis in Section 4.3.2.2. The results of each model specification are presented independently. The purpose is to compare the estimated coefficients across specifications to identify whether the global AFFM explains a greater proportion of returns.

The results of this section address the four research questions presented in Section 4.1. For Section 4.3.2.1, comparing the results of the global AFFM against existing asset pricing models will address research questions 1 and 2, regarding the impact of commodities and stock market risk factors, respectively. Further, comparing the estimated coefficients across various sector portfolios will address research question 3, the inter-sectoral comparison. The inter-temporal results in Section 4.3.2.2 will address research question 4, using annual global AFFM regressions. Regression diagnostic tests identify heteroskedasticity and autocorrelation across sector portfolios, also reported in Table 4.5. All coefficients are estimated using Newey-West (1987) HAC covariance matrices. The Variance Inflation Factors (VIFs) found no evidence of multicollinearity. The following section addresses the four asset pricing models.

TABLE 4.5: CAPM, FAMA-FRENCH AND AUGMENTED ASSET PRICING MODELS

This table presents the Newey-West regression output for the 11 sectors, using four model specifications. The 11 value-weighted sector portfolios include the: energy utility ($\boldsymbol{R_{util,t}}$), bank ($\boldsymbol{R_{banks,t}}$), oil & gas ($\boldsymbol{R_{O\&G,t}}$), telecommunication ($\boldsymbol{R_{tele,t}}$), industrial ($\boldsymbol{R_{ind,t}}$), insurance ($\boldsymbol{R_{ins,t}}$), retail ($\boldsymbol{R_{ret,t}}$), technology ($\boldsymbol{R_{tech,t}}$), media ($\boldsymbol{R_{media,t}}$), chemical ($\boldsymbol{R_{chem,t}}$), and financial ($\boldsymbol{R_{fin,t}}$) sectors. The nine risk factors include: market premium ($\boldsymbol{R_{m,t}}$), size premium (SMB_t), value premium (HML_t), momentum premium (UMD_t) term premium ($\boldsymbol{R_{tp,t}}$), oil price risk ($R_{o,t}$), coal price risk ($R_{c,t}$) and natural gas price risk ($R_{g,t}$). A ****, ***, ** or * denotes significance at 0.1%, 1%, 5% or 10%, respectively. Reported coefficients and significances have been corrected for any autocorrelation or heteroskedasticity. Specifications are:

Equation (4.1), CAPM: $\boldsymbol{R}_{i,t} = \alpha_i + b_i\boldsymbol{R}_{m,t} + e_{i,t}$,

Equation (4.2), Augmented-CAPM: $\boldsymbol{R}_{i,t} = \alpha_i + b_i\boldsymbol{R}_{m,t} + tp_i\boldsymbol{R}_{tp,t} + o_iR_{o,t} + c_iR_{c,t} + g_iR_{g,t} + e_{i,t}$,

Equation (4.3), four-factor: $\boldsymbol{R}_{i,t} = \alpha_i + b_i\boldsymbol{R}_{m,t} + s_iSMB_t + h_iHML_t + m_iUMD_t + e_{i,t}$

Equation (4.4), global AFFM: $\boldsymbol{R}_{i,t} = \alpha_i + b_i\boldsymbol{R}_{m,t} + s_iSMB_t + h_iHML_t + m_iUMD_t + tp_i\boldsymbol{R}_{tp,t} + o_iR_{o,t} + c_iR_{c,t} + g_iR_{g,t} + e_{i,t}$,

where $\boldsymbol{R}_{i,t}$ denotes one of the 11 sectors as the dependent variable.

Sector	**Model**	α_i	b_i	s_i	h_i	m_i	tp_i	o_i	c_i	g_i	$\boldsymbol{Adj.R^2}$	$\boldsymbol{F =}$	$\boldsymbol{p}$	**Mean VIF**	**Heterosked.**	**Autocorr.**
Energy Utilities	(4.1)	-0.0001	0.7218 ****								0.6696	1852.86	****	1.00	84.95 ****	33.978 ****
	(4.2)	-0.0001	0.7227 ****				-0.0017	0.0109	-0.0371 ****	0.0020	0.6717	486.99	****	1.00	73.23 ****	31.462 ****
	(4.3)	-0.0001	0.6887 ****	-0.1362 ****	0.2409 ****	0.0510 ****					0.6863	520.46	****	1.28	77.98 ****	25.058 ****
	(4.4)	-0.0001	0.6896 ****	-0.1369 ****	0.2368 ****	0.0512 ****	-0.0117	0.0113	-0.0323 ***	0.0019	0.6879	347.80	****	1.14	70.28 ****	23.268 ****
Banks	(4.1)	-0.0001	1.2378 ****								0.8077	4726.40	****	1.00	144.88 ****	92.766 ****
	(4.2)	-0.0001	1.2385 ****				-0.1010	-0.0115	-0.0267 *	0.0012	0.8082	992.56	****	1.00	162.53 ****	91.640 ****
	(4.3)	-0.0001	1.1720 ****	0.0385	0.6011 ****	-0.1623 ****					0.8773	1947.37	****	1.28	156.26 ****	54.438 ****
	(4.4)	-0.0001	1.1723 ****	0.0386	0.6004 ****	-0.1619 ****	-0.0982	-0.0097	-0.0067	-0.0003	0.8774	1044.05	****	1.14	172.83 ****	52.859 ****
Oil & Gas	(4.1)	0.0000	0.9354 ****								0.5776	2404.05	****	1.00	18.75 ****	2.913 *
	(4.2)	0.0000	0.9345 ****				-0.0277	0.0719 ****	0.0033	0.0082 **	0.5845	537.28	****	1.00	15.34 ****	0.507
	(4.3)	0.0000	0.8827 ****	-0.2322 ****	0.2298 ****	0.0536 **					0.5878	711.32	****	1.28	23.50 ****	2.133
	(4.4)	0.0000	0.8806 ****	-0.2356 ****	0.2315 ****	0.0529 **	-0.0383	0.0724 ****	0.0076	0.0085 **	0.5949	388.10	****	1.14	19.13 ****	0.909
Telecom.	(4.1)	0.0000	1.0126 ****								0.6535	3552.28	****	1.00	0.11	103.082 ****
	(4.2)	0.0000	1.0128 ****				0.0116	-0.0153 *	0.0106	-0.0066 *	0.6538	728.08	****	1.00	0.01	99.986 ****
	(4.3)	0.0001	0.9490 ****	-0.3849 ****	-0.3757 ****	-0.0147					0.6931	1113.95	****	1.28	0.01	68.568 ****
	(4.4)	0.0001	0.9497 ****	-0.3836 ****	-0.3758 ****	-0.0146	0.0181	-0.0154 *	-0.0007	-0.0044	0.6932	568.98	****	1.14	0.17	65.855 ****
Industrial	(4.1)	0.0000	0.9870 ****								0.8521	8133.39	****	1.00	3.33 *	28.490 ****
	(4.2)	0.0000	0.9872 ****				0.0090	0.0019	-0.0151 *	0.0036 *	0.8523	1654.54	****	1.00	3.25 *	27.982 ****
	(4.3)	-0.0001	1.0638 ****	0.3991 ****	0.0840 ****	-0.0207 **					0.8759	2897.96	****	1.28	5.10 **	21.010 ****
	(4.4)	-0.0001	1.0641 ****	0.3987 ****	0.0825 ****	-0.0207 **	0.0115	0.0016	-0.0110	0.0020	0.8759	1464.94	****	1.14	4.99 **	20.138 ****
Insurance	(4.1)	-0.0001	1.2900 ****								0.8104	6491.01	****	1.00	3.73 *	38.745 ****
	(4.2)	-0.0001	1.2910 ****				0.0344	-0.0100	-0.0393 ****	0.0041	0.8113	1318.77	****	1.00	4.80 **	37.853 ****
	(4.3)	0.0000	1.2125 ****	-0.0466	0.3933 ****	-0.1896 ****					0.8505	2343.45	****	1.28	0.21	16.975 ****
	(4.4)	0.0000	1.2133 ****	-0.0471	0.3897 ****	-0.1893 ****	0.0433	-0.0085	-0.0248 ***	0.0033	0.8509	1185.47	****	1.14	0.63	16.203 ****
Retail	(4.1)	-0.0001	0.7794 ****								0.7079	5695.37	****	1.00	10.28 ***	3.763 *
	(4.2)	-0.0001	0.7792 ****				0.0113	-0.0177 ***	0.0093	0.0009	0.7084	1162.51	****	1.00	11.00 ****	2.915 *
	(4.3)	-0.0001	0.8180 ****	0.1657 ****	-0.0107	0.0086					0.7122	1485.73	****	1.28	11.04 ****	2.714 *
	(4.4)	-0.0001	0.8179 ****	0.1661 ****	-0.0098	0.0087	0.0117	-0.0180 ***	0.0094	0.0003	0.7128	758.31	****	1.14	11.60 ****	1.949

Table 4.5 (Continued)

Sector	**Model**	α_i	b_i	s_i	h_i	m_i	tp_i	o_i	c_i	g_i	$\boldsymbol{Adj. R^2}$	$\boldsymbol{F =}$	$\boldsymbol{p}$	**Mean VIF**	**Heterosked.**	**Autocorr.**
Technology	(4.1)	-0.0001	1.3174 ****								0.6513	2779.74	****	1.00	0.07	7.044 ***
	(4.2)	-0.0001	1.3165 ****				-0.0366	-0.0084	0.0432 ***	-0.0049	0.6519	594.05	****	1.00	0.55	7.320 ***
	(4.3)	0.0001	1.2770 ****	-0.2820 ****	-0.8871 ****	-0.1522 ****					0.7250	981.83	****	1.28	0.05	0.462
	(4.4)	0.0001	1.2765 ****	-0.2813 ****	-0.8844 ****	-0.1524 ****	-0.0071	-0.0091	0.0213	-0.0020	0.7250	530.28	****	1.14	0.15	0.479
Media	(4.1)	-0.0002	0.9802 ****								0.6881	4299.07	****	1.00	0.37	92.787 ****
	(4.2)	-0.0002	0.9795 ****				0.0237	-0.0039	0.0267 ****	-0.0008	0.6885	870.16	****	1.00	0.26	93.035 ****
	(4.3)	-0.0002 *	1.0725 ****	0.3376 ****	-0.4594 ****	-0.0432 **					0.7256	1367.68	****	1.28	0.76	64.404 ****
	(4.4)	-0.0002 *	1.0721 ****	0.3380 ****	-0.4575 ****	-0.0434 **	0.0386	-0.0051	0.0164 **	-0.0010	0.7256	688.55	****	1.14	0.57	64.315 ****
Chemicals	(4.1)	0.0002	0.9143 ****								0.6890	4085.12	****	1.00	6.42 **	5.354 **
	(4.2)	0.0002	0.9148 ****				0.0229	0.0009	-0.0252 **	0.0039	0.6894	820.76	****	1.00	7.12 ***	5.524 **
	(4.3)	0.0002	0.9018 ****	0.0100	0.2172 ****	-0.0048					0.6983	1083.48	****	1.28	12.22 ****	3.705 *
	(4.4)	0.0002	0.9022 ****	0.0093	0.2145 ****	-0.0047	0.0192	0.0014	-0.0192 *	0.0034	0.6985	541.90	****	1.14	13.17 ****	3.845 **
Finance	(4.1)	-0.0001	1.2199 ****								0.8610	7199.18	****	1.00	159.36 ****	100.526 ****
	(4.2)	-0.0001	1.2206 ****				-0.0595	-0.0090	-0.0276 **	0.0018	0.8615	1509.12	****	1.00	176.75 ****	99.419 ****
	(4.3)	-0.0001	1.1642 ****	0.0463	0.4936 ****	-0.1549 ****					0.9172	3074.47	****	1.28	204.27 ****	49.034 ****
	(4.4)	0.0000	1.1646 ****	0.0463	0.4922 ****	-0.1545 ****	-0.0551	-0.0075	-0.0107	0.0005	0.9173	1663.27	****	1.14	223.39 ****	47.288 ****

4.3.2.1 The Four Asset Pricing Models

The CAPM

The CAPM, Equation (4.1), captures the relationship between the sector returns and the market factor. The coefficient b_i is statistically significant across all sectors. The mean b_i is 1.036. Being close to unity, the mean b_i indicates that the selection of sectors is a good proxy for average stock returns in Europe. Estimated coefficients range from 0.722 to 1.317, showing differential systematic risk exposure. The expectation is that utilities will rank among the most defensive European sectors, with a beta less than unity. As stated in Section 3.2.2.3, Fama and French (1993) show that the range between the maximum and minimum coefficients, multiplied by the average risk factor's return, can be used to calculate the estimated spread in expected returns due to the differential impact of the risk factor; this method is adapted for annualised returns. The spread between high- and low-b_i stocks is 0.596. The product of the coefficient spread and annualised excess market factor return of 0.95% per annum (extracted from Table 4.2) shows that the estimated spread in expected returns, between the highest and lowest b_i stocks, is 0.563% per annum. This small difference is expected as the full time period analysed includes the dot-com crisis, GFC and EUC, resulting in low annualised return for the market factor. High-b_i stocks which appreciate in value during economic booms also lose greater value during economic downturns. Low-b_i stocks experience smaller magnitudes of gains and losses through time. Fama and French (1993) also find a spread in b_i of 0.53 between high- and low-b_i stocks; however, the average annualised excess market return in their time period was greater (5.28% per annum), resulting in a large spread in estimated returns due to systematic risk exposure. The intercepts in Table 4.5 are insignificant across all sectors analysed, showing that the CAPM captures most of the spread in average returns (Fama and French, 1993).

As expected, the European energy utility sector has a b_i of 0.722, making the sector a defensive investment. The energy sector has the lowest systematic risk of all sectors analysed and falls within the range of market betas shown in the previous literature (Table 3.1). The oil & gas sector's estimated b_i is 0.935, indicating greater systematic risk exposure which is closer to unity, further evidence that the two sectors have unique characteristics.

The mean adjusted R^2 of the CAPM is 72.44%, ranging from 57.76% to 86.10%. For the energy utility sector, the CAPM explains 66.96% of the total variation in returns. In comparison, Fama and French (1997) find that the CAPM explains 55% of return variance in utilities (which may include water and waste firms and therefore is not representative of energy-specific utilities). Although the market beta is expected to be the greatest determinant of average energy utility returns, macroeconomic and stock market risk factors serve as likely candidates to explain the fraction of variance unexplained (FVU) by the CAPM. The following section begins to address research question 1 by examining the impact of term premium, oil, coal and natural gas price risk using the augmented-CAPM (see Section 3.2.2).

The Augmented CAPM

The results of the augmented-CAPM (Equation 4.2), across multiple sectors, can be compared with Faff and Brailsford (1999); see Section C.1 of Appendix C. The comparison shows that the results are qualitatively the same, with only minor differences.

Across 10 of the sector portfolios reported in Table 4.5, the augmented-CAPM and CAPM specifications produce estimated b_i coefficients which are identical to two decimal places; the b_i coefficients for the media sector is identical to one decimal place. The spread between high- and low-b_i stocks is 0.594 and the market factor continues to explain a difference of 0.56% per annum in expected return spread. The minor change in b_i indicates that term premium and commodities are relatively unimportant determinants of asset returns, but have some minor role in asset pricing (Chen et al., 1986). This can be observed from the mean adjusted R^2, which increases to 72.56%; the term premium and commodity risk factors only explain an additional 0.12% of return variance. The minor impact is also evident in the oil & gas sector, where revenues and profitability are related to commodity prices. Despite statistically significant commodities and the greatest oil price risk coefficient, the adjusted R^2 for oil & gas sector only increases from 57.76% to 58.45%. The following paragraphs address the estimated coefficients for term premium and each commodity. The term premium results can be compared with various papers, while oil price risk can be compared with Faff and Brailsford (1999), who perform an equivalent analysis on Australian industries. Comparisons for the impact of natural gas and coal price risk are restricted to the energy utility and oil & gas literature (see Section 3.2.3 and Table 3.1).

Term premium represents the state of the economy and the costs of borrowing funds in the short term (Fama and French, 1993, Sadorsky, 2001). The mean coefficient for term premium, tp_i, is -0.010, ranging from -0.101 to 0.034. The coefficients for term premium are insignificant across all sectors, suggesting that term premium has no significant impact across the entire time series. Although insignificant, the coefficient spread of 0.135 shows that the estimated spread in expected annualised returns for sectors due to term premium is 0.95% per annum, small in both statistical and economic terms. The lack of significance is unsurprising, as previous literature shows inconsistencies in the relationship with term premium and stock returns, finding positive (Fama and French, 1993, Ramos and Veiga, 2011, El-Sharif et al., 2005), negative (Sadorsky, 2001, Boyer and Filion, 2007), and no significant impact (Oberndorfer, 2009a) – with the latter representing the most comparable results (see Sections 3.2.3.2 and 3.2.3.3).

Oil price risk shows significant impacts on three of the sectors analysed. The mean oil coefficient, o_i, is 0.001, ranging from -0.018 to 0.072. The estimated spread in expected returns due to oil price risk is 0.94% between high- and low-oil-sensitive sectors. Across time, oil price risk is insignificant for the energy utility sector. Naturally, the oil & gas sector is the most sensitive to oil price risk, with a positive coefficient of 0.072, $p \leq 0.001$, accounting for an additional 0.75% of expected returns per annum. Faff and Brailsford (1999) also find a positive and significant coefficient of 0.23 for oil price risk in the Australian oil & gas sector. The telecommunication and retail sectors show negative coefficients of -0.015 ($p = 0.084$) and -0.018 ($p = 0.002$), respectively. The directions of the negative coefficients are similar to Faff and Brailsford's (1999) results for the communications[50] and retail sectors, having coefficients of -0.09 and -0.04, respectively. In contrast, Faff and Brailsford (1999) find that the coefficients are insignificant relative to other risk factors.

Coal accounts for around 32% primary energy consumption globally (ITRE Committee, 2014). Coal is especially important in electricity production. Accordingly, the impact is expected to be negative for energy-intensive sectors. The mean coefficient for coal price risk, c_i, is -0.007, ranging from -0.039 to 0.043; the spread in coal coefficients is 0.082. The spread in expected returns as a result of coal price risk is 0.35% per annum, small in economic terms. Coal is significant and negative for the energy utility sector, with a coefficient of -0.037, $p = 0.001$, decreasing expected returns in the sector by approximately 0.16% per annum. These results are consistent with Oberndorfer (2009a), who finds a significant coefficient of -0.01 for the European electricity industry. Increasing (decreasing) coal prices decreases (increases) operating profitability. Koch and Bassen (2013) find varying significance for individual firms. Surprisingly, many of the other sector portfolios also show significant positive and negative coal price risk.

The result of significant coal risk across multiple sectors arouses curiosity. It is possible that coal price risk proxies for additional risk factors not yet specified. For example, increasing energy prices may negatively impact energy-intensive sectors such as the chemical and industrial sectors if at least some of the rising cost of coal is reflected in energy prices. It does not explain why coal price risk is significant for sectors which are expected to have no

---

[50] Regarding the comparison, Faff and Brailsford (1999) classify the 'communication services' sector within the ASX 'Media' industry.

commodity risk exposure, such as the bank, financial, insurance, media and technology sectors. Moreover, it does not explain why the results show both positive and negative coefficients.

The most plausible explanation is misspecification of the asset pricing model, suffering from an omitted variable. This chapter posits that coal price risk is only significant in the absence of stock market risk factors, which typically explain a greater proportion of equity returns. This proposition arises from the pairwise correlation in Table 4.4 which shows that coal returns have a negative correlation with the HML factor of -0.057, where 1) the correlation between coal and the HML factor is of greater magnitude than coal's correlation with any sector, and 2) the HML and sector correlations are all of greater magnitude than coal's correlations with sectors. The expectation is that the inclusion of the HML factor in the asset pricing model will reduce coal's significance due to some interaction between the two variables. In addition, the HML coefficients will be in the opposite direction to coal, congruent with the negative coal-HML pairwise correlation. Referring to the literature of Section, 3.2.2, Fama and French (1992, 1993, 1996) show that book-to-market typically relates to various characteristics of firm distress, while Fama and French (1995) show that high-BE/ME firms typically have persistently low earnings. This will suggest that at least some of the impact from coal price risk actually represents firm distress which would otherwise be captured by the HML factor. If true, then the results suggest that commodities which have previously been found to be significant may proxy for stock market risk factors; that is, previous conclusions may have been *false positives*.

Natural gas is used as both a fuel in electricity generation and an output benchmark for gas production. The mean coefficient for natural gas price risk, g_i, is 0.001, ranging from -0.007 to 0.008. The coefficient spread is small, only 0.015. The spread in expected returns as a result of natural gas sensitivities is only 0.17% per annum. Results find that natural gas has no significant impact on the energy utility sector as a whole, congruent with Oberndorfer (2009a) and Koch and Bassen (2013). Energy utilities are expected to hedge against natural gas price fluctuations in the long term. The oil & gas and industrial sectors show significant coefficients for natural gas price changes of 0.008 ($p = 0.03$) and 0.004 ($p = 0.073$), respectively. The increasing price of natural gas contributes an additional 0.10% per annum to the oil & gas industry. The telecommunication sector has a negative coefficient of -0.007 ($p = 0.076$). Despite the statistical significance, the overall economic impacts of natural gas are small and oil price risk is a far more important determinant of expected returns.

Overall, the results of both Oberndorfer (2009a) and this chapter show that the risk exposure of the energy utility sector is different to that of the oil & gas sector, particularly with regard to the systematic risk and commodity risk exposure. The results above begin to address research question 1: term premium and commodities do have an impact on the energy utility sector, but the impact is small. Importantly, the ability to detect any commodity risk exposure suggests that energy utilities have not fully realised the benefits of energy risk management. The very minor increase in adjusted R^2 and unusual coal price risk suggests that other factors may better explain return, leading to research question 2. The following section presents the results of the four-factor model of Fama and French (1993) and Carhart (1997) introduced in Section 3.2.2. Term premium and commodities are excluded as the model extends the original CAPM specification.

The Four-Factor Model

Table 4.5 presents the results for the four-factor model (Equation 4.3). These results for the four-factor model are compared with Fama and French (1997) in Section C.2 of Appendix C. The four-factor model includes stock market risk factors expected to affect stock returns, see Section 3.2.2 for a review of the literature and Section 4.2.4 for the calculation of the global stock market risk factors. The results for the four-factor model, Equation (4.3), show the same inter-sectoral variability as Fama and French (1997). While the results allow inter-sectoral comparison, Fama and French (1997) show that global risk factors typically perform poorly at the local level. Chapter 5 addresses how to adapt the four-factor model for industry-level analysis, increasing the goodness of fit for energy utilities in isolation.

First, the stock market risk factors are statistically significant in the majority of cases. The size premium (SMB) is significant for 7 of the 11 sector portfolios tested, the value premium (HML) is significant for 10 of the 11 portoflios tested and momentum premium (UMD) is significant for 8 of the 11 portfolios tested. The significant coefficients are evidence that the global stock market risk factors capture returns across a variety of sectors. The inclusion of the stock market risk factors also increases the mean adjusted R^2 from 72.44% with the CAPM specification to 75.90% in the four-factor specification. The additional risk factors are responsible for explaining an additional 3.46% of variation in equity returns, consistent with Fama and French (1993, 1997), implying a greater role in asset pricing than term premium and commodity risk factors. The inclusion of the stock market risk factors affects the estimated market beta coefficients. The additional risk factors must capture average return which was previously absorbed by the CAPM's market factor, congruent with Fama and French's (1993) argument that the market factor is a 'hodgepodge' of multiple stock market risk factors. With the exception of the industrial, retail and media sectors, most market betas show a small decrease in magnitude. Fama and French (1993) find that inclusion of the SMB and HML factors typically collapses the market betas for portfolios towards unity; Section 3.2.2.3 discussed possible causes of this. With the inclusion of SMB, HML and UMD, the mean market beta is 1.018, ranging from 0.689 to 1.277, a spread of 0.588. Despite the different estimated coefficients, the spread in expected returns between the most aggressive and defensive stocks remains consistent with the CAPM, an expected return spread of 0.56% per annum. For the energy utility sector, the b_i coefficient is 0.689, $p \leq 0.001$, lower than the previous estimates, but shows that energy utilities continue to remain a defensive investment through time.

The mean SMB coefficient, s_i, is -0.008 across all 11 sectors, ranging between -0.385 and 0.399, a spread of 0.784. The spread in expected returns due to the size premium is large in both economic and statistical terms: 5.31% per annum. For the energy utility sector, the SMB coefficient is -0.136. The negative SMB slope shows that the energy sector behaves like big European stocks.[51] The expected returns are -0.92% per annum as a result of size premium. However, the SMB factor is measured against global market level data, and therefore estimates the size premium relative to all European stocks. An industry-level size premium may yield different results and will more accurately estimate the economic impact of size premium (again, this is addressed in Chapter 5).

The HML coefficient is highly statistically significant, but its economic effect is small. The mean HML coefficient, h_i, is 0.048, ranging from -0.887 to 0.601, a spread of 1.488. Despite the large coefficient spread, the descriptive statistics in Table 4.2 show that the daily return on the HML factor is not significantly different from zero, with an annualised return of 0.43%. In economic terms, the spread in expected returns across sectors due to the value premium is 0.64% per annum. For the energy utility sector, the estimated HML coefficient is 0.241, $p \leq 0.001$. The results suggest that the energy sector's returns covary with the returns on high-BE/ME European stocks; behaving like distressed European stocks. Chapter 6 examines whether regulatory changes are the source of energy sector distress. The product of the coefficient spread and annual return on the HML factor suggests that the value premium

---

[51] As discussed in Section 4.2.4, the SMB factor represents a zero investment portfolio which is long on small European stocks and short on big European stocks. As small European stocks are expected to outperform big European stocks, a negative SMB coefficient shows that the returns in the European energy utility sector covary with the returns on big European stocks, moving opposite to the SMB factor. The interpretation of the negative slope on the SMB factor is consistent with Fama and French (1997) and adopted for the remaining stock market risk factors.

contributes 0.104% to annual return, small in economic terms. Again, an industry-specific HML factor may provide more accurate results (see Chapter 5).

The momentum premium has a real economic impact at the market level. The mean UMD coefficient, m_i, is -0.057, ranging from -0.190 to 0.054, with a spread of 0.243. The prevalence of negative coefficients may be due to the financial crises that occurred during the time series, where firms that were previously performing well were negatively affected by global economic downturns. Despite the smaller spread, the UMD risk factor produced a daily return of 0.031% ($p = 0.071$), an equivalent of 8.45% per annum. This return is congruent with Jegadeesh and Titman (1993), Carhart (1997) and Moskowitz and Grinblatt (1999), who find that momentum explains between 8% and 12% of returns annually. The product of the coefficient spread and annualised returns yields an expected return spread of 2.06% per annum across sectors. For the energy utility sector, the estimated UMD coefficient was 0.051, $p \leq 0.001$. Both Carhart (1997) and Moskowitz and Grinblatt (1999) also find significant momentum after controlling for size and value premia. The result suggests the returns of the energy utility sector behave like upper momentum European stocks. Based on market level UMD, the risk factor contributed 0.43% to expected annual returns, small in economic terms.

Addressing research question 2, the stock market risk factors explain a greater proportion of returns in the energy utility sector. In particular, size and momentum appear to be major determinants of returns. Overall, the results are also fairly consistent with Fama and French (1993, 1997). While the market beta continues to be the most significant risk factor in explaining average returns, additional stock market risk factors show strong statistical significance and help explain returns previously absorbed by the market factor. Moreover, the impact of the stock market factors also varies across sectors. In economic terms, the results show that the major differences between sectors' expected returns are influenced by size and momentum factors.

Further, in the case of energy utilities some interesting observations can be made. First, the SMB coefficient shows that returns of the energy sector behave like big European stocks, suggesting that the returns on big energy utilities dominate energy sector returns. This was a major motivation for the three packages of liberalisation in Section 2.2.1, designed to counteract the dominant and predatory behaviour of the largest energy utilities. As late as 2013, energy utilities still complained of misuse of networks and unfair grid access and network fees (ACER, 2013). Second, the HML coefficient shows that energy utilities behave like distressed firms relative to other European stocks. This is certainly consistent with the expectation of increased risk exposure from liberalisation and environmental objectives; see the academic literature in Sections 3.3.2 and 3.3.3. The results are also consistent with utilities facing a range of policy-induced challenges which are materially affecting their financial return; see Section 1.1. Finally, the UMD coefficient suggests that returns of European energy utilities were consistent with upper momentum European stocks, possibly indicating excess returns and/or oligopoly power argued in Section 1.2. However, it must be acknowledged that this is a static picture of sector returns over the last two decades. The inter-temporal analysis in Section 4.3.2.2 will address the time-varying nature of these relationships.

The Global AFFM

As noted in the introduction to this chapter (Section 4.1), a principal objective of this chapter is to develop the global AFFM by combining the energy economics and finance asset pricing models, producing an asset pricing model that captures a greater proportion of sector returns. The results of the global AFFM, Equation (4.4), are included in Table 4.5. Noticeably, term and commodity premia have a minor contribution to explaining stock returns. The inclusion of term and commodity premia only increases the adjusted R^2 of the CAPM by 0.12%, while global AFFM's mean adjusted R^2 is only 0.09% greater than the four-factor specification. Moreover, the inclusion of the stock market risk factors also reduces the magnitude and significance of term and commodity premia.

Where significant, the stock market risk factor coefficients between the four-factor model and global AFFM are identical to two decimal places. The significant commodity coefficients between the augmented-CAPM and global AFFM are mostly identical to at least one decimal place. Term premium remains insignificant across specifications. The inclusion of the additional stock market risk factors (SMB, HML and UMD) has little impact on the significant oil and natural gas coefficients, but affects estimated coal coefficients. For the energy utility sector, the coal coefficient reduces from -0.037 ($p \leq 0.001$) to -0.032 ($p = 0.005$). Further, the inclusion of the additional stock market risk factors nullifies the anomalous significant coal coefficients for the bank, industrial, technology and financial sectors. Significance is reduced for the insurance, media and chemical sectors. Further, the significant HML coefficients for all the aforementioned sectors are opposite to the significant coal coefficients found previously. As argued above, coal price risk must have captured some element of the HML factor, a proxy for firm distress, and therefore becomes insignificant, or weakened, when modelled simultaneously.

Overall, the global AFFM is able to incorporate both the augmented-CAPM and the four-factor model into a single asset pricing model. The goodness of fit of the global AFFM is also greater compared with the remaining model specifications in isolation. The following addresses research questions 1 to 3 of this chapter using the global AFFM.

For research question 1, the results show that coal is the only commodity to have a significant impact on energy sector returns, with the impact being negative. For research question 2, stock market risk factors explain a much greater proportion of average returns compared with term and commodity premia. The inclusion of the stock market risk factors increases the mean adjusted R^2 by 3.46% for the four-factor model compared with the CAPM specification. The factors also collapse most market betas. Further, the inclusion of the HML factor reduces some impact from coal price risk. Addressing research question 3, the node network and multivariate regression in Table 4.5 indicate that returns in the energy sector are different to the other European sectors. The results of the asset pricing models in Table 4.5 show that the risk exposure among sectors varies greatly.

Table 4.6 provides a summary of the differential impact of significant risk factors from the global AFFM. Table 4.6 shows that there is heterogeneous risk exposure across European sectors. The unique risk exposure of the energy sector suggests that sector must be examined in isolation for a more accurate understanding of required rates of return on investment and equilibrium asset pricing; this is addressed in Chapter 5. The following Section (0) examines results of the conditional annual global AFFM regressions, addressing research question 4: inter-temporal variability of the risk premia.

TABLE 4.6: SUMMARY OF DIFFERENTIAL IMPACT OF RISK FACTORS

This table summarizes the impact of significant risk factors from the global AFFM in Table 4.5, where a “$+$” indicates a significant positive coefficient was observed, and “$-$” indicates a significant negative coefficient was observed.

	α_i	b_i	s_i	h_i	m_i	tp_i	o_i	c_i	g_i
Energy Utilities		+	-	+	+			-	
Banks		+		+	-				
Oil & Gas		+	-	+	+		+		+
Telecommunications		+	-	-			-		
Industrials		+	+	+	-				
Insurance		+		+	-			-	
Retail		+	+				-		
Technology		+	-	-	-				
Media	-	+	+	-	-			+	
Chemical		+		+				-	
Finance		+		+	-				

4.3.2.2 Inter-Temporal Analysis

As stated in Section 3.3.4, previous studies have reported substantial inter-temporal, inter-sectoral and transnational variability in the relationship between average returns and risk factors (Faff and Brailsford, 1999, Sadorsky, 2001, El-Sharif et al., 2005, Oberndorfer, 2009a, Fama and French, 1997, 1998, 2012). The results reported in Table 4.5 are estimated over the entire time period, 1996 to 2013, yet Fama and French (1997) argue that industry risk loadings vary through time. To address this issue, the time series is separated into annual periods and the conditional global AFFM, Equation (4.5), is implemented on a year-by-year basis. This method mimics the six-month conditional regressions of El-Sharif et al. (2005). Table 4.7 reports the coefficients for the energy utility sector, estimated using Newey-West HAC standard errors and subject to standard regression diagnostic tests. Figure 4.6 illustrates the estimated coefficients from Table 4.7 and includes the 95% confidence intervals – if the spread between the confidence intervals overlap zero, the coefficient is generally insignificant at $p = 0.05$. The benefit of this approach is that carbon price risk can be included, as the time series begins in mid 2005.

The inter-temporal results in Table 4.7 show that the impact of the market factor is consistently positive and significant through time. The market beta has also been increasing through time, with an upward shift in beta occurring in 2005. The result shows the energy utility sector is becoming increasingly exposed to systematic risk and losing its role as a defensive investment asset. This increase in market beta was also observed by Kane and Unal (1988), who found increasing market risk in the banking sector as a result of deregulation objectives. Chapter 6 will formally test the effect of policy on the energy sector.

Of the 18 annual coefficients, 16 SMB coefficients are nominally negative, where 10 are statistically significant. The negative SMB slope indicates that the energy utility returns continue to behave like big European stocks, consistent with the argument that big utilities dominate the sector at the expense of small utilities. Despite regulatory changes designed to counteract the dominance of big energy utilities, see Section 2.2.1, the impact has generally become more negative, more frequent and more significant through time. The majority of significant coefficients occur post-2006. The removal of national barriers would allow big energy utilities to rapidly expand into previously isolated international markets.

For the HML coefficients, 13 are nominally positive. Of the seven statistically significant HML coefficients, six are positive and one is negative. The positive coefficients indicate that the energy utility sector behaved like high-BE/ME European stocks; suggesting the sector was distressed relative to other European stocks. The significant impact typically occurs one to two years after the three packages of liberalisation (1996 and 1998, 2003 and 2009); see Section 2.2. In particular, the energy sector becomes extremely distressed post-2010. Again, this coincides with the third packages of liberalisation which were expected to be a major regulation regarding market power and dominance issues; see Section 2.2.1. The only year the energy sector behaves like low-BE/ME (growth) stocks is 2009; however, all European stocks lost value during the GFC.

TABLE 4.7: INTER-TEMPORAL ANALYSIS OF SECTOR PORTFOLIO USING THE GLOBAL AFFM

This table presents conditional global AFFM, estimated on a year-by-year basis using Newey-West HAC standard errors. Due to the method of portfolio construction, see Section 4.2.4, coefficients are estimated between July 1996 and June 2013. The value-weighted returns of the energy sector ($\boldsymbol{R_{util}}$) is used as the dependent variable. The nine risk factors include: market premium ($\boldsymbol{R_m}$), size premium (SMB), value premium (HML), momentum premium (UMD) term premium ($\boldsymbol{R_{tp}}$), oil risk (R_o), coal risk (R_c), natural gas risk (R_g) and carbon risk (R_{co2}). The intercept and error term are denoted α_i and e_i, respectively. A ****, ***, ** or * denotes significance at 0.1%, 1%, 5% or 10%, respectively. The specification used is:

$$\boldsymbol{R_{util}} = \alpha_i + b_i\boldsymbol{R}_m + s_i SMB + h_i HML + m_i UMD + tp_i\boldsymbol{R_{tp}} + o_i R_o + c_i R_c + g_i R_g + co2_i R_{co2} + e_i.$$

Year	α_i	b_i	s_i	h_i	m_i	tp_i	o_i	c_i	g_i	$co2_i$	$\boldsymbol{adj.R^2}$	$\boldsymbol{F =}$	***Sig.***
1996[A]	0.0001	0.7097 ****	0.0235	-0.0783	0.1261	0.4969 **	-0.0093	-0.0068	-0.0103		62.97%	28.85	****
1997	0.0000	0.6736 ****	-0.1109 *	0.0286	0.0192	-0.0630	0.0050	-0.0217	0.0069		74.29%	94.93	****
1998	0.0005	0.5775 ****	-0.1084	0.1805 **	-0.0203	0.1329	0.0153	-0.0675 ***	-0.0022		70.80%	79.82	****
1999	-0.0010 ***	0.5885 ****	-0.1546 *	0.0324	-0.1496 ***	0.1361	0.0028	0.0074	-0.0115		60.33%	50.42	****
2000	0.0006	0.4410 ****	-0.0598	0.1933 **	-0.0475	-0.3820	0.0044	-0.0133	0.0013		28.54%	13.93	****
2001	0.0001	0.6556 ****	-0.1659 **	0.1190	0.2398 ****	-0.0413	0.0231	-0.0249	-0.0002		65.77%	63.45	****
2002	0.0001	0.7365 ****	-0.1358	0.0205	0.1708 ****	-0.1153	-0.0145	0.0164	0.0017		82.00%	149.04	****
2003	0.0002	0.5879 ****	-0.2791 **	-0.0167	-0.0666	0.3680	-0.0015	-0.0932 **	0.0008		77.54%	113.22	****
2004	0.0005 *	0.6131 ****	-0.1496	0.2000 *	-0.0412	0.3273	0.0139	-0.0279	0.0010		60.96%	51.94	****
2005	0.0003	0.8039 ****	0.0025	0.3147 ***	0.0608	0.2150	-0.0188	-0.0004	-0.0010		61.52%	52.77	****
2006	0.0007 ***	0.7190 ****	-0.3271 ****	0.0872	-0.0007	0.0427	0.0555 ***	-0.0128	0.0023	0.0058	70.04%	68.29	****
2007	0.0002	0.5971 ****	-0.2470 ***	-0.0179	0.3115 ****	0.1287	0.0294	0.0046	0.0007	0.0009	70.65%	70.52	****
2008	0.0005	0.9639 ****	-0.5269 ****	-0.0322	0.3794 ****	0.4811	0.0356	-0.0596 **	0.0038	-0.0046	85.63%	173.86	****
2009	-0.0003	0.9186 ****	-0.2111 **	-0.4089 ****	0.0885 **	-0.1344	0.0392 **	0.0017	-0.0026	0.0065	72.18%	75.95	****
2010	-0.0021	0.8687 ****	-0.1156	0.0200	-0.2999 ****	0.9574	0.0512 **	-0.0435 **	0.0014	-0.0023	84.10%	153.81	****
2011	-0.0001	0.8371 ****	-0.3433 ***	0.4124 ****	-0.0391	-0.0213	0.0080	0.0031	0.0106	-0.0002	84.90%	162.86	****
2012	-0.0009	0.6423 ****	-0.3565 ***	0.5229 ****	-0.0848	0.3064	-0.0100	-0.0069	-0.0033	0.0004	71.07%	71.96	****
2013[A]	-0.0023	1.0370 ****	-0.0646	0.1194	-0.4751 ****	1.2821	-0.0787	-0.0118	-0.0507	0.0108	70.30%	34.66	****
Mean	-0.0002	0.7206	-0.1850	0.0943	0.0095	0.2287	0.0084	-0.0198	-0.0029	0.0022	69.64%		

[A] Due to rebalancing in June, data contains six months of observations.

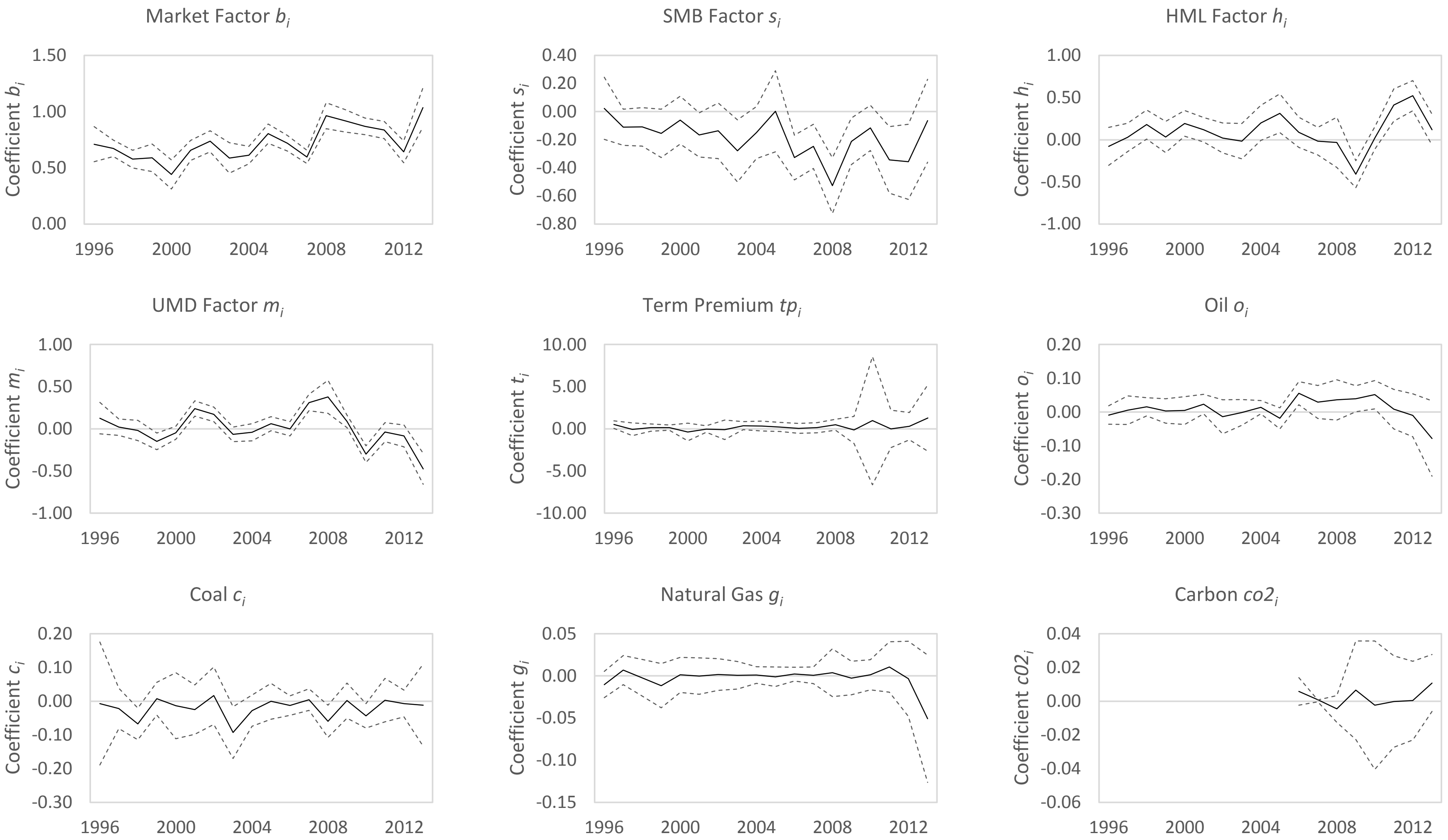


FIGURE 4.6: ESTIMATED GLOBAL AFFM COEFFICIENTS AND 95% CONFIDENCE INTERVALS THROUGH TIME

This figure illustrates the estimated coefficients for the nine risk factors through time, using the annual global AFFM results from Table 4.7. The solid line represents the estimated coefficient, while the dotted line represents the 95% confidence interval. When the 95% confidence interval overlaps zero, the test of significance fails at the 5% level

Of the UMD coefficients, 10 are nominally negative and eight are nominally positive. The UMD factor is significant on eight occasions; three are negative and five are positive. The positive coefficients show that the sector generally behaves like upper momentum European stocks sporadically through time. The negative coefficients in 1999, 2010 and 2013 suggest that the energy utility sector behaves like poorly performing European stocks. The negative 1999 coefficient coincides with the first packages of liberalisation: the expectation is that energy utilities which benefited (suffered) from the previous regulatory environment now lose (gain) market share as dominance issues are addressed, market borders are removed and liberalisation induces competition; see Section 2.2.1. Negative coefficients are observed following the second packages of liberalisation in 2003, but lack significance. The GFC, EUC and third packages of liberalisation (2009) also show negative estimated UMD coefficients in the following years. The GFC and EUC result in an economic downturn in Europe where past winners are likely to have become past losers. Further, the third package of liberalisation addressed outstanding market dominance issues. Overall, the UMD factor appears to capture the shift when past winners (losers) become losers (winners).

Consistent with El-Sharif et al. (2005), Table 4.7 shows varying commodity risk exposure over time. Based on the number of significant coefficients through time, coal was the most significant commodity, followed by oil, term premium, then gas – where gas showed no significance through time. Coal price risk through time is consistent with expectations. All significant coefficients are negative, similar to Oberndorfer (2009a). Consistently negative coefficients suggest that an increase in coal prices negatively impacts the energy utility sector. When combined with Figure 4.3 and Figure 4.4 (Plot G), the results appear to show significant coal coefficients in the years which experience large increases in coal prices or increased volatility of coal returns. It is possible that the coal price sensitivity represents the impact of unexpected fluctuations in coal price, which would disadvantage coal-intensive industries. The detection of coal price risk suggests that energy utilities have not fully realised the benefits of coal risk management, failing to hedge against coal price fluctuations.

Where significant, oil coefficients in Table 4.7 are always positive. The positive relationship between oil returns and energy utility returns suggests evidence of the long-term relationship between crude oil prices and firm value (El-Sharif et al., 2005, Oberndorfer, 2009a, Narayan and Gupta, 2015). This result is unusual as the energy utilities sector rarely uses oil in production and generation; however, El-Sharif et al. (2005), Oberndorfer (2009a) and Koch and Bassen (2013) also find significant oil price risk for European oil & gas and energy utilities. Oberndorfer (2009a) argues that energy utilities prices may be benchmarked against oil prices. Term premium is only significant in the last six months of 1996 and insignificant thereafter, whereas natural gas price risk is insignificant throughout the entire time series. Oberndorfer (2009a) finds that term premium is insignificant for European energy utilities. Both Oberndorfer (2009a) and Koch and Bassen (2013) also find no significant natural gas coefficients for European energy utilities. As the price of natural gas has changed drastically over the time period, as shown in Figure 4.3 and Figure 4.4 (Plot H), the lack of significance indicates effective natural gas risk management.

A pooled regression is only valid if the economic relationship remains stable over the full period tested. Results from Table 4.7 show that this is not the case, as stock market, term premium, and commodity risk factors have intertemporal variability and evolve over time. The implications of the inter-temporal results are that the pooled regression in Table 4.5, which is often the approach in the energy economics literature, is invalid over the full period. However, the inter-temporal approach of El-Sharif et al. (2005) also induces a range of methodological issues which induce bias in coefficient estimates and significance. Chapter 5 will introduce an inductive structural breakpoint test which more accurately identifies breakpoints in the relationship between sector returns and risk factors series, improving coefficient estimates and producing less bias significance test.

4.4 Conclusion

This chapter conducts an analysis on the determinants of returns in 11 European sectors. The aim of the chapter was to develop an asset pricing model which improves upon the CAPM, augmented-CAPM and four-factor models by reintegrating the energy economics and finance literatures. The global AFFM specifications examines the impact of four stock market risk factors (market factor, and the size, value and momentum premia), term premium and four commodities (oil, coal, natural gas and carbon). The novel global AFFM, developed in this chapter is used to answer the following research questions: 1) to what extent do commodity price changes impact the returns in the European energy utility sector, 2) could stock-market risk factors better explain the variation in energy utilities' returns; 3) do the impacts reflect market-wide conditions or the sector-specific relationships between returns and risk premia and 4) are these risk premia time-varying?

The main results regarding the model show that the stock market risk factors of the global AFFM are mostly significant, and their inclusion captures a greater proportion of variation in stock returns, across all European sectors, compared with other asset pricing models. The global AFFM provided the greatest goodness of fit, as judged by the mean adjusted R^2 of 75.99%, compared with the CAPM (72.44%), the augmented-CAPM (72.56%), and the four-factor model (75.90%). In the case of energy utilities in isolation, the global AFFM captures 68.79% of sector returns, an improvement over the 66.96% from the CAPM specification. The increased goodness of fit across sectors was attributable to the three additional stock market risk factors, which were mostly significant across all sectors tested. The term premium and commodity risk factors showed some statistical significance, but contributed less to the overall goodness of fit. Further, the economic impact on expected annual returns due to the differential spread in commodity risk exposure was small – typically less than 1% per annum.

Answering the research questions, commodities are found to impact returns in the European energy utility sector, but the impact is relatively low. In particular, coal price risk negatively impacts the sector and oil price risk positively impacts the sector; term premium and natural gas are mostly insignificant. As utilities are expected to hedge against natural gas price fluctuations, this may be the result of effective hedging strategies. While the negative impact of coal is congruent with expectations in electricity production, the positive impact from oil price risk is unusual, since energy utilities rarely use oil in electricity production; however, the results are consistent with the significant oil risk exposure found by Oberndorfer (2009a).

The stock market factors are routinely found to improve the goodness of fit across all sectors analysed. The market factor, size, value and momentum premia are mostly significant across all sectors – the latter three variables experienced some insignificance. Overall, the market factor remains the greatest determinant of sector returns. Term premium and commodities often lose, or show lower significance when competing against stock market factors. Interestingly, the results show that the returns of energy utilities continue to behave like big European stocks. From a policy perspective, this confirms the motivation of the three packages of liberalisation – published with an aim of counteracting market dominance issues from big energy utilities. The sector also behaves like distressed European stocks, and typically behave like well-performing (upper momentum) European stocks.

By comparing the significant risk factors for all sectors, the results show that the impact of stock market factors, term and commodity premia are unique across sectors. This demonstrates that impacts reflect sector-specific relationships with risk factors. The results show that the risk profile of energy utilities is unique in comparison with other European sectors – including the oil & gas sector. In fact, the results discredit the assumption that risk factors which affect the oil & gas sector can be assumed true for the energy utility sector. Comparing the two sectors, the energy utility sector has lower systematic risk, is less sensitive to size premium and is sensitive to coal price risk. In contrast, the oil & gas sector has greater systematic risk, has greater exposure to size premium and has greater exposure to oil and natural gas price risk. Energy utilities share elements of risk with many sectors of the economy and typically have the lowest systematic risk exposure of all sectors analysed. The differential impact of each sector is consistent with Faff and Brailsford (1999) and Fama and French (1997).

The fourth research question addresses the stability of risk premia in the European energy utility sector. On a year-by-year basis, results suggest that the risk premia are time varying. Energy utilities appear to be losing their role as a defensive investment asset, with a market beta which is increasing towards unity; this suggests the sector is becoming riskier. The size premium shows that the dominance from big utilities has, in fact, worsened rather than improved as markets have become liberalised through time. The spread between big utilities and small utilities is increasing. This is a major blow for liberalisation policy since it was supposed to benefit small and new-entrant companies (see Section 2.2). The value premium is increasing in magnitude through time, with the European energy utility sector becoming increasingly distressed relative to other European stocks. The momentum premium shows time-varying characteristics. In most years, energy utilities were winners (upper momentum) relative to other European stocks. However, in 1999, 2010 and 2013, the energy sector performed poorly relative to European stocks. The interpretation is that the sector receives exogenous shocks which significantly shift the operating environment. Perhaps regulatory changes, formally examined in Chapter 6, result in past winners (losers) becoming future losers (winners). Term, oil and coal premia show sporadic significance through time. Term premium is only significant in late-1996, oil is significant and positive for three of the years analysed, while coal price risk is significant and negative for four of the years analysed. Natural gas and carbon price risk is consistently insignificant through time.

4.4.1 Contribution

This chapter contributes to the literature in many ways. Energy economics authors have identified that the current literature is somewhat restricted due to the reliance on limited explanatory variables, and that the integration of additional variables, such as the stock market risk factors of Fama and French (1993) and Carhart (1997), will be of interest to the energy economics literature (El-Sharif et al., 2005, Oberndorfer, 2009a). This chapter addresses this niche, developing an asset pricing model by reintegrating energy economics and finance literature which is able to capture a greater proportion of return variation and addresses many criticisms of estimating market beta using the CAPM and augmented-CAPM, as highlighted in Section 3.2.2.

In producing a superior asset pricing model, this chapter also makes qualitative and methodological contributions. Methodologically, the improved asset pricing model helps establish a more accurate equilibrium asset pricing function by incorporating both the augmented-CAPM and the four-factor model into a single asset pricing model. This model can be used in a variety of applications which require estimates of stock returns, and has implications for modelling average returns at the sector level. Further, this chapter reduces bias in estimated coefficients by creating a much larger sample of energy utility companies compared with the most relevant energy economics papers (Oberndorfer, 2009a, Koch and Bassen, 2013). Moreover, the sample controls for survivorship bias which ensures that the risk factors are estimated for the average company at the time, rather than the firms which have survived regulatory changes and competition.

Qualitatively, this chapter demonstrates that sectors are not homogenous and have differential impacts to stock market, term premium and commodity risk factors. In particular, results confirm that the energy utility sector and the oil & gas sector are dissimilar and should be independently analysed. Lack of inter-sectoral and inter-temporal generalisability of results shows that the impact of risk factors is time-varying. The ability to detect commodity risk exposure, which varies over time, suggests that energy utilities have not fully realised the benefits of energy risk management and production hedging. Further, the results make a major contribution to energy policy by being the first to empirically show that big energy utilities do indeed outperform small energy utilities, unlike many other sectors, which was a motivation for major regulatory changes in the sector.

From this point, the thesis can continue by further refining the global AFFM to calculate stock market risk factors at the industry level. This adjustment should increase the overall goodness of fit and provide more accurate estimations of the impacts from size, value and momentum premia at the sector level. This will be used to better understand which types of energy utilities are driving average sector returns. Chapter 5 will also examine the heterogeneity of 12 portfolios of energy utilities grouped on firm characteristics, including the whole sector; small and big utilities; value, neutral and growth utilities; upper and down momentum utilities; and electricity, natural gas and multi-utilities. Overall, Chapter 5 will provide greater insight into the risk exposure of energy utilities and various types of utilities within the sector.

4.4.2 Limitations

No empirical analysis is without limitation. The following paragraphs outline potential limitations and steps taken to address these limitations. Empirical models can fail due to poor construction of mimicking value and momentum portfolios. To address this limitation, Appendix A compared the mimicking portfolios constructed in this chapter to those of French (2015). The mimicking risk factors constructed in this chapter are found to be comparable. Further, the four-factor model has been routinely implemented in empirical finance literature, representing one of the most robust and scrutinised research methods which has stood the test of time. This chapter simply extends this established model to sector-specific propositions.

Another limitation, highlighted by Fama and French (1997, 2012), concerns the fact that the stock market risk factors typically have low power at the local level. To address this limitation, Chapter 5 calculates the risk factors using sector level data rather than market level data. The overall result should be stock market factors which more accurately represent the spread between small and big, value and growth and upper and down momentum between energy utilities. However, it should be noted that without market level data the industry comparisons would not be possible, so both analyses serve their own purpose. Qualitatively, the results of Chapter 5 are in the same direction as those observed in this chapter, but show increased goodness of fit. Consequently, a range of further diagnostics are implemented on the results of Chapter 5.

From an econometrics perspective, an anticipated limitation regarding the conditional global AFFM is the estimation of risk factors on an annual basis. While it may be true that the risk premiums are time-varying, the annual regressions are tantamount to assuming that the risk factors undergo a structural break annually, with the break point occurring on the same day of each year. Econometrically this assumption is incorrect and most likely to be invalid. Specifically, the approach includes too few or surplus observations, depending where in fact the true structural break lies, which can bias estimated coefficients and result in unstable estimates. However, this method is implemented in the energy economics literature (see El-Sharif et al., 2005). Empirical finance has previously attempted to overcome this obstacle using rolling regressions. However, Fama and French (1997) show that the rolling regression approach is rarely more precise than the full-period approach. Chapter 5 also shows that the annual regression approach contributes little to the model's goodness of fit compared with the full-period regressions. Chapter 5 introduces recent econometric advances in the estimation of structural break points, which drastically improves the ability to detect structural breaks in risk factors and improves the overall model's goodness of fit.

CHAPTER 5

REFINING THE AFFM AND EXPLORING WITHIN-SECTOR HETEROGENEITY

5.1 Introduction

This chapter deepens the understanding of the risk factors in European energy utility returns by refining the AFFM developed in Chapter 4 for through four analytical foci, namely: 1) calculating stock market risk factors at the sector level, creating a local AFFM; 2) applying the local AFFM to sub-group portfolios of European utilities so as to explore within-sector heterogeneity; 3) applying inductive rather than deductive structural break point tests (see Section 3.3.4); and 4) better isolating the firm-specific component of returns. In combination, addressing the four foci allows for a more nuanced understanding of the impact of risk factors on sector returns.

To address foci 1 and 2, this chapter must define the difference between the global (market level) and local (sector level) stock market risk factors. Figure 5.1 assists with understanding the subtle but important difference. Chapter 4 utilises global stock market risk factors, calculated using all 600 European stocks (see Section 4.2.4), defining the spread in average returns between the smallest and largest European stocks, the highest- and lowest-BE/ME European stocks, and upper and down momentum European stocks. The empirical analysis in Chapter 4 (Section 4.3.2) examines the relationship between the returns of each sector portfolio and the stock market risk factors for Europe. Using Figure 5.1, the focus of Chapter 4 is, therefore, between levels A and B. The global approach of Chapter 4 has the advantage that it allows for an understanding of how the energy sector behaves *relative to other European stocks and sectors*. However, as stated in Section 4.4.2, the 'global' are limited as they perform poorly at 'local' level, since local models are typically better at explaining local average returns (Fama and French, 1997, 2012). To examine what drives average returns *within* the energy utility sector, this chapter explores the relationship between the returns of the energy sector and local, sector-level risk factors. Therefore, using Figure 5.1, this chapter is concerned with levels B and C. For example, do returns in the energy utility sector behave like big or small *energy utilities*? The literature review in Section 5.2 will show that there may be greater informational content *within* a sector, compared with informational content across an entire market.

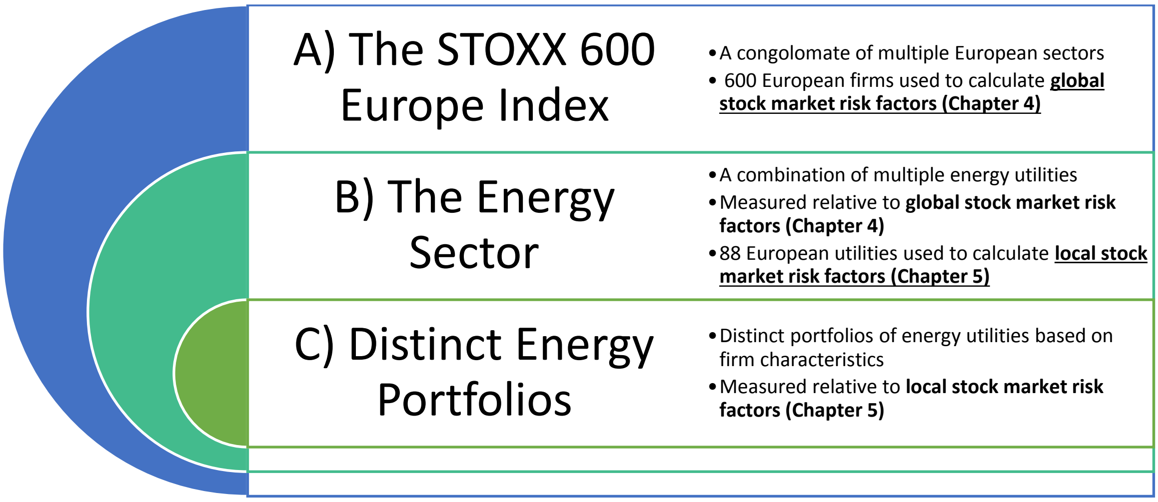


FIGURE 5.1: LEVELS OF ANALYSIS AND THE DISTINCTION BETWEEN GLOBAL AND LOCAL RISK FACTORS

This figure illustrates the levels of analysis for Chapters 4 and 5. While Chapter 4 focuses on levels A and B, the focus of Chapter 5 is on levels B and C. Chapter 4 utilised global stock market risk factors, while chapter 5 utilises local stock market risk factors.

To address foci 3 and 4, the econometrics literature in Section 3.3.4 argued that the deductive approach to testing break points can lead to bias significance tests, unless the breaks are known with certainty. Surplus observations which are unaffected by structural breaks skew the mean residuals towards zero, reducing the power of statistical tests and biasing significance tests (Quandt, 1960). Structural breaks can cause pure and partial changes in model parameters (see Section 3.3.1), affecting the firm-specific component returns after filtering out systematic components (Fama and French, 1993, Hansen, 2001). This has implications for isolating abnormal returns as a result of regulatory changes, the focus of Chapter 6.

This chapter makes both academic and policy contributions. There are three academic contributions from this chapter. First, the chapter outlines a modelling approach for implementing sector studies regarding asset pricing. This chapter shows that local (sector level) stock market risk factors explain a greater proportion of sector returns compared with global (market level) stock market risk factors. For the energy sector, the adjusted R^2 increases from 68.79% using the global AFFM (see Table 4.5) to 72.77% using the local AFFM (see Table 5.5). Second, this chapter identifies within-sector heterogeneity, examining the risk exposure of various energy utilities grouped on similarity of characteristics. This is a substantial contribution over previous papers concerning asset pricing of European energy utilities, which have examined only portfolios of energy utilities versus oil companies (Oberndorfer, 2009a) or high- versus low-carbon emitters (Koch and Bassen, 2013). In total, this chapter examines 12 portfolios of energy utilities grouped on firm characteristics, namely: the energy sector as a whole; small and big utilities; high-BE/ME (value), mid-BE/ME (neutral) and low-BE/ME (growth) utilities; upper, medium and down momentum utilities; and electricity, natural gas and multi-utilities. Third, this chapter introduces recent econometric advances in the estimation of structural break points (see Section 3.3.4). The Bai and Perron (1998; 2003) structural break point test identifies significant structural breaks in the relationship between returns and risk premia through time. The inductive method of controlling for structural breaks improves the local AFFM's adjusted R^2 to 80.42%. Further, this chapter implements the Bai and Perron (1998; 2003) break point test on the residuals of an unconditional AFFM regression, showing that almost 28% of the residuals' variance, normally assumed to be the firm-specific component of returns, can be attributed to the changing relationship between sector returns and risk premia. Put simply, this chapter does a better job of isolating the firm-specific component of returns and filtering out systematic risk factors.

The descriptive results show that the return profile of the 12 portfolios are distinct from one another. Similar to Chapter 4, the local AFFM results show that commodities contribute little to explaining average returns in the energy portfolios, while stock market risk factors such as size, book-to-market ratio and momentum are important determinants of average returns across the 12 portfolios. Importantly, the local AFFM has better regression fit using the stock market risk factors and allows deeper insight into the heterogeneous commodity risk exposure of various energy portfolios. Further, the inter-temporal analyses show a clear shift in the return profiles of energy utilities, beyond macroeconomic variables. There have been clear shifts in momentum surrounding the second and third packages of liberalisation, 2003 and 2009, respectively. The third packages have dramatic impacts on the magnitude and significance of most risk factors. Prior to the third packages, the energy sector behaves like low-BE/ME (growth) and upper momentum utilities. From 2009 onwards, the sector behaves like down momentum energy utilities and high-BE/ME (value) utilities, typically associated with firm distress. While still a defensive stock, utilities are taking on increasing systematic risk through time. Further, the energy sector appears to be taking on increasing commodity risk exposure.

Regarding the policy contributions, there is large heterogeneity in the return profiles of various energy utilities based on firms' characteristics, providing important policy implications with regard to understanding the evolving risk exposure of utilities. Small utilities have lower systematic risk than big energy utilities, but have greater commodity risk exposure implying that small utilities may not fully utilise the benefits of commodity hedging. While the size premium is expected to exist, small and big utilities also have a spread in value premium which shows that small utilities are typically more distressed than big utilities.

Regarding the industry profiles, the natural gas utility portfolio shares many similarities with the oil & gas sector of Chapter 4. The natural gas sector also has greater systematic risk compared with the electricity and multi-utility portfolios. While most utilities have negative momentum, only the natural gas portfolio has persistently positive returns across time. The electricity industry has greater cumulative returns compared with other industry portfolios, suggesting a greater risk-return relationship. The asset pricing models show that the electricity industry is distressed relative to other utilities, which is argued to be the impact of regulations relating to competition and renewables (see, respectively, Section 2.2.1 and 2.2.3). This firm distress increases post-GFC. Electricity utilities have negative momentum in the years surrounding the second and third packages of liberalisation. Post-GFC, the electricity industry is taking on increasing commodity risk; again, suggesting a failure to effectively hedge commodity risk. The overall results indicate that electricity utilities are riskier than the natural gas and multi-utility industries. Interestingly, the multi-utilities showed one of the lowest cumulative abnormal returns across all portfolios – possibly indicating a lower risk-return relationship. The multi-utilities have less commodity risk exposure than both the natural gas and electricity industries. This is consistent with economy of scope – diversified operations allow multi-utilities to switch operations when faced with regulatory changes or fluctuations in commodity prices.

The structure of this chapter is as follows. Section 5.2 outlines the chapter-specific literature review regarding the use of local stock market risk factors in asset pricing models, Section 5.3 outlines the methodology of the chapter; Section 5.4 presents the descriptive and econometric results of the various asset pricing models, the inter-temporal analysis and the structural break point test; and Section 5.5 provides a concluding discussion.

5.2 Literature Review: Local Stock Market Risk Factors

The following paragraphs present the prior literature relevant to this chapter regarding the performance of the asset pricing models at the sector level. Since Fama and French (1993), various papers have documented that sector level peculiarities with regard to the stock market risk factors can be a major influence in capturing variation in stock returns.

Fama and French (1997) represents one of the most important papers exploring the sector level performance of the CAPM and the three-factor model, employing both models on 48 U.S. industries between 1963 and 1994. They find that the choice between the two models can result in large differences in the valuation of investments; the cost of equity calculation differs by more than 2% for 17 industries and more than 3% for eight industries. Fama and French (1997) argue that discrepancies in the cost of equity estimates at the sector level are partly caused by estimation error in the SMB and HML slopes. The most likely cause for the large estimation error arises from the return profiles of a sector differing to that of the market as a whole. This is evident in the variety of coefficients previously observed in Table 4.4 and Table 4.5; each European sector has differential sensitivities to risk premia.

Further motivation for examining returns using sector level data comes from Boni and Womack (2006), who argue that stock analysts specialise by sector. Boni and Womack (2006) examine momentum information signals of future relative winners and losers from sector specialists between 1996 and 2002, requiring analysts to create relative ranking of firms within their specialised sector. Results show that a sector-based momentum recommendation strategy substantially improves the returns relative to risk borne and reduces price momentum tilt relative to portfolios which ignore sector-specific information. Buying upgraded firms versus selling short downgraded firms yields returns of 1.23% the following month, even after controlling for the Fama and French (1993) and Carhart (1997) stock market risk factors. Of the 57 sectors analysed, 54 produced nominally positive returns, while 16 produced positive and statistically significant returns; none were significantly negative. The overall conclusion is that sector-specific analysts are good stock pickers within their sector of expertise, and investors acknowledge that the analysts' information is valuable with respect to identifying within-sector mispricing. The implications of the results with regard to future research suggests that beyond controlling for stock market, term premium and commodity risk factors, the within-sector characteristics also need to be accounted for (Boni and Womack, 2006). Similar to Boni and Womack (2006), Moskowitz and Grinblatt (1999) show that momentum strategies are poorly diversified, with winners and losers often being derived from the same sector or industry.

Moskowitz and Grinblatt (1999) examine whether sector level momentum helps explain average returns for 20 sector portfolios, between 1963 and 1995. The paper focuses on the positive persistence (momentum) of stock returns over intermediate investment horizons, up to 24 months. They hypothesise that sector level momentum is a major determinant of average returns within a sector. The results show that sector portfolios exhibit significant momentum, even after controlling for size, BE/ME and individual stock momentum. This is likely due to the fact that stocks within a sector tend to be highly correlated (Schwert, 1981, Moskowitz and Grinblatt, 1999); see Section 3.3.5.1. The high correlation among firms may be due to a variety of reasons, including 1) operating within the same regulatory environment, 2) exhibiting similar behaviour regarding corporate finance, 3) having similar sensitivity to macroeconomic forces and 4) having exposure to similar supply and demand fluctuations (Moskowitz and Grinblatt, 1999). Moskowitz and Grinblatt (1999) argue that aggregating stocks into sector portfolios for momentum calculation eliminates much of the firm-specific component of returns, minimising the dispersion in the unconditional mean.

As noted in Section 3.2.1, and illustrated in Figure 3.1, the market beta was unable to capture the total dispersion of observations around its expected value. Fama and French (1993) argued that stock market risk factors serve as likely candidates to explain this (unconditional) expected return. To paraphrase, the crux of Moskowitz and Grinblatt's (1999) argument is that the sector-level stock market risk factors will do a better job at capturing this unexplained variance.

Fama and French (2012) compare the performance of global and local four-factor model specifications across four regions between 1989 and 2011, including North America, Europe, Japan and Asia Pacific. They conclude that asset pricing regressions on a regional basis typically have greater explanatory power as regression fits are tight, resulting in higher R^2 values. The calculation of global stock market risk factors is only suitable for global comparisons, for example, in the case of the inter-sectoral analysis in Chapter 4. To explain average returns at the local level, i.e. *within* the energy sector, the use of a local model is preferable. While this may lose generalisability to other sectors, calculating the stock market risk factors at the sector level reduces dispersion in the unconditional mean for the risk factors and provides a more accurate measurement of the impact of size, value and momentum on average returns.

This chapter presents a similar argument: the informational content in the sector-level risk factors have greater relevance to explaining sector returns compared with global risk factors, which must inevitably include stocks *outside* the sector which have different firm characteristics.

5.3 Methodology

The following section outlines the model and econometric approach to exploring returns at the sector level. Section 5.3.1 outlines the econometric models and approach used to answer the four analytical foci. Section 5.3.2 presents the sample and data used. Section 5.3.2.1 outlines the construction of the 12 portfolios used as dependent variables in the local AFFM. In contrast, Section 5.3.3 outlines the calculation of the local stock market risk factors used as independent variables of the local AFFM.

5.3.1 Models and Econometric Approach

The analysis in Chapter 4 shows that the global AFFM is better at explaining returns in the energy utility sector in comparison with existing asset pricing models (see Table 4.5

and chapter contributions in Section 4.4.1). To examine returns at the sector level, this chapter develops the local AFFM. The local AFFM of this chapter will be used to answer analytical foci 1 and 2. To answer focus 1, this chapter will compare the adjusted R^2 values between the global and local AFFMs of Chapter 4 and 5, respectively. To answer focus 2, this chapter will explore within-sector heterogeneity by examining the returns across 12 European energy utility portfolios. For convenience, energy portfolio returns are denoted in the generalised form $\boldsymbol{R}_{i,t}$, where $\boldsymbol{R}_{i,t}$ denotes the excess return over the one month UK treasury bill for the i^{th} portfolio on day t (see forthcoming Section 5.4.1.1). The econometric modelling begins with the local AFFM, estimated using OLS regressions:

$$\begin{aligned}\boldsymbol{R}_{i,t} &= \alpha_i + b_i\boldsymbol{R}_{m,t} + s_iLSMB_t + h_iLHML_t + m_iLUMD_t \\ &\quad + tp_i\boldsymbol{R}_{tp,t} + o_iR_{o,t} + c_iR_{c,t} + g_iR_{g,t} + e_{i,t},\end{aligned} \tag{5.1}$$

where α_i denotes the intercept, b_i denotes the market coefficient, $\boldsymbol{R}_{m,t}$ denotes the excess return on the market factor at time t, s_i denotes the local SMB coefficient, $LSMB_t$ denotes the local size premium at time t, h_i denotes the local HML coefficient, $LHML_t$ denotes the local value premium at time t, m_i denotes the local UMD coefficient, $LUMD_t$ denotes the local momentum premium at time t, tp_i denotes the term premium coefficient, $\boldsymbol{R}_{tp,t}$ denotes the term premium at time t, o_i denotes the oil price risk coefficient, $R_{o,t}$ denotes the return on oil price at time t, c_i denotes the coal price risk coefficient, $R_{c,t}$ denotes the return on coal price at time t, g_i denotes the natural gas price risk coefficient and $R_{g,t}$ denotes the return on natural gas price at time t.

Despite superficially similar model specifications, there are two major differences between the global and local AFFMs. First, the global AFFM of Chapter 4, Equation (4.4), is used to explain returns across 11 distinct sectors of European stocks (see Section 4.2.3.1). In contrast, the local AFFM in Equation (5.1) is used to explain returns across 12 portfolios of European energy utilities grouped on similarity of characteristics (see Section 5.3.2.1). Second, the global AFFM in Equation (4.4) uses global stock market risk factors calculated across a diversified sample of 600 European stocks as independent variables, with the objective of creating an integrated global AFFM which can be applied across sectors; see Section 4.2.4 for SMB_t, HML_t and UMD_t calculations. In contrast, the local AFFM in Equation (5.1) will calculate stock market risk factors using the 88 European energy utilities as independent variables, with the objective of more accurately explaining within-sector returns; see Section 5.3.3 for the $LSMB_t$, $LHML_t$ and $LUMD_t$ calculations.

For completeness and comparability between Chapters 4 and 5, this chapter will also report the econometric results of the CAPM, augmented-CAPM and four-factor model (using local stock market risk factors $LSMB_t$, $LHML_t$ and $LUMD_t$). For brevity, we utilise the same model specifications as Chapter 4: Equations (4.1), (4.2) and (4.3), respectively. Conditional annual local AFFM regressions are implemented to remain consistent with Chapter 4 and examine time-varying risk premia. Further, the conditional regressions allow comparison of the deductive approach against the inductive approach of estimating unknown break dates using the Bai and Perron (1998, 2003) test, discussed below. Accordingly, the following equation is implemented on an annual basis between 1996 and 2013:

$$\begin{aligned}\boldsymbol{R}_i = \alpha_i + b_i\boldsymbol{R}_m + s_iLSMB + h_iLHML + m_iLUMD \\ +tp_i\boldsymbol{R}_{tp} + o_iR_o + c_iR_{co} + g_iR_g + co2_iR_{co2} + e_i \qquad (5.2)\end{aligned}$$

where $co2_i$ denotes the carbon price risk coefficient and R_{co2} denotes the return on carbon. Similar to Chapter 4, the regressions are estimated using Newey-West HAC standard errors, and subject to standard regression diagnostic tests.

Research foci 3 and 4 focus on addressing parameter stability and isolation of the firm-specific components of returns using an inductive approach. To this end, this chapter employs the Bai and Perron (1998; 2003) structural break point test to examine the presence of multiple structural changes in model parameters (discussed in Section 3.3.4). The Bai and Perron (1998; 2003) break point test is implemented using *EViews* and contains two stages: 1) a *post-hoc* multiple break point test and 2) the break point regression; explains below.

The first stage implements post-hoc stability diagnostic tests on the results of the local AFFM in Equation (5.1). The multiple break point test identifies whether there are potential break points in the unconditional AFFM's model parameters. The break specification is sequential, testing the null of ℓ versus the alternative of $\ell + 1$ breaks. The information criterion is set to allow up to 18 structural breaks, the maximum available, and employs a trimming percentage of 5%. As the dataset consists of 4,435 observations, the trimming value implies that regimes must have at least 222 observations to be considered a structural break; this was the minimum period permissible by the model. The significance level is $p \leq 10\%$, and error distributions are allowed to differ across breaks to control for heterogeneity. The results of the test report an estimate for the number of potential breaks in the sample and the estimated break dates.

The second stage implements a break point regression specifying the local AFFM as the mean equation (Equation 5.1). The break point regression estimates a linear regression where the parameters are subject to structural change. The algorithm obtains global minimisers of the SSR based on dynamic programming. Based on evidence of heteroskedasticity and autocorrelation, Newey-West HAC standard errors for the coefficient covariance matrix are used and error distribution is allowed to differ across breaks to account for heterogeneity of time periods. The results of Bai and Perron (2003) showed that this allowed for detection of smaller break which were otherwise obscured in the data (see Section 3.3.4.2). The HAC coefficient covariance matrix automatically determines optimised lag structuring using the Akaike Information Criterion[52] (AIC). The kernel bandwidth is automatically determined using Andrew's AR(1) method and uses quadratic-spectral kernels. To remain congruent with the first stage, the break specification is also sequential, testing the null of ℓ versus the alternative of $\ell + 1$ breaks. The information criterion is also set to allow a maximum of 18 structural breaks, employs a trimming percentage of 5% and tests significance at $p \leq 10\%$. The test will estimate the date of structural breaks in the relationship between returns in the energy sector and the risk premia of the local AFFM. The results also report the estimated coefficients across each of the break dates, allowing examination of the changing relationship with risk premia through time.

In Section 5.4.2.4, the isolation of the firm-specific component of returns is explored using the unconditional local AFFM (Equation 5.1), using the conditional annual local AFFM (Equation 5.2) and using the Bai and Perron (1998; 2003) structural break point test.

5.3.2 Sample Selection and Data

The data used in this chapter are the same as that used in Chapter 4 (see Section 4.2.3) with one addition, namely the use of SICs to group energy utilities based on their industry sub-grouping. For the classification of European energy utilities by industry (electricity, natural gas or multi-utility), SICs for the years 1996 to 2013 were obtained from Thomson Reuters Datastream and allow for the creation of industry-portfolios, defined by the primary source of revenue for a firm within a given year. As a requirement to be eligible for analysis, all energy utilities must have data on stock price, market capitalisation, book value of equity for years t and $t - 1$ and SICs for year t. This did not affect the number of companies used in the sample. For consistency across chapters, the sample of European energy utility companies used in this chapter are the same 88 energy utilities outlined in Section 4.2.2. As stated earlier (see Sections 1.5 and 4.1), the sample is still considerably larger than that of Oberndorfer (2009a) and Koch and Bassen (2013), who examine 22 and 20 European utilities, respectively.

---

[52] Note, three alternative lag structures were also tested but made no difference to estimates: 1) no lag specification, 2) Schwarz information criterion and 3) Hannan-Quinn Information Criterion.

5.3.2.1 Returns to be explained: the 12 energy portfolios

In Chapter 4, the focus of the global AFFM was to examine returns for the energy utility sector as a whole, where the size, value and momentum premia were only used as explanatory variables on the RHS of the regression models (see Equation 4.4). In contrast, focus 2 of this chapter (Section 5.1) seeks to identify within-sector heterogeneity for the European energy utility sector. To this end, beyond examining average returns for the energy sector as a whole, the 88 European energy utilities are also sorted into various portfolios based on similarity of characteristics. The groupings, outlined in the following paragraphs, produce a further two portfolios based on size, three portfolios based on BE/ME ratios, and three portfolios based on momentum and three portfolios based on firm industry. In total, 12 portfolios are examined. This method of industry grouping is a novel contribution to the energy economics literature and is also an improvement on Oberndorfer (2009a) and Koch and Bassen (2013).

The value-weighted returns of the 12 portfolios become dependent variables on the LHS of the local AFFM in Equation (5.1) (see Section 5.3.1) and the three ancillary asset pricing models: CAPM, augmented-CAPM and local four-factor model. The purpose of the portfolio approach is to examine the within-sector heterogeneity of energy utility returns based on firm characteristics. The benefit of this approach is the ability to examine risk exposure of particular utilities in isolation; for example, the risk exposure of small utilities. Whereas the method of portfolio construction in Chapter 4 (Section 4.2.4) creates the size, value and momentum premia for use as independent variables, the method is adapted in this chapter to create 12 energy portfolios for use as dependent variables. The rest of this section outlines portfolios constructed for use as dependent variables, while Section 5.3.3 outlines portfolios used as independent variables.

The following paragraph constructs the two size portfolios. At the end of June of each year t, from 1996 to 2013, all European energy utilities are ranked on market capitalisation to proxy for size. Annually, the median market capitalisation is used as the break point to allocate the energy utility stocks into two portfolios: small or big energy utilities. Value-weighted returns are calculated for the small and big portfolios from July of year t to end of June for $t+1$, denoted $\boldsymbol{R_{small}}$ and $\boldsymbol{R_{big}}$. The portfolios are rebalanced annually at the end of June for $t+1$. Visual inspection showed that the two portfolios were well balanced each year, containing approximately equal numbers of energy utilities with a maximum difference of one firm when the sample contained an odd number of energy utilities. The median number of energy utilities in the $\boldsymbol{R_{small}}$ and $\boldsymbol{R_{big}}$ portfolios, across all years, was 22.5. Although balanced, big energy utilities typically dominated sector valuation. Between 1996 and 2013, the combined value of small energy utilities accounted for 6.4% of total sector valuation. This is consistent with Chapter 4 and Fama and French (1995). For the portfolio of 600 European firms in Chapter 4, small firms typically accounted for 5.84% of the total market value, across all firms and years. Similarly, Fama and French (1995) found that small firms accounted for about 7.3% of total market value in 1991. The $\boldsymbol{R_{small}}$ and $\boldsymbol{R_{big}}$ portfolios will be used as dependent variables in Equation (5.1) to examine heterogeneous risk exposure based on utility size.

To form the three BE/ME portfolios, all energy utilities are ranked on their BE/ME ratios annually. The BE/ME ratio is calculated as the book value of common equity for the fiscal year ending in calendar year $t-1$, scaled[48] by market capitalisation at the end of December in year $t-1$. The energy utilities are allocated to groups based on Fama and French's (1993, 1995, 1997, 1998, 2006, 2012) three break points: the top 30% (high-BE/ME), the middle 40% (mid-BE/ME) and the bottom 30% (low-BE/ME). The three groups represent value, neutral and growth stocks, respectively (Fama and French, 2006, 2012, French, 2015). Negative BE/ME firms are excluded from break point calculations and BE/ME portfolio formation; the sample only contained two negative BE/ME observations. The high, mid and low BE/ME portfolios contain a median of 13, 18 and 13.5 firms, respectively, across all years. Value-weighted returns are calculated for the high-BE/ME, mid-BE/ME and low-BE/ME portfolios, denoted $\boldsymbol{R_{high}}$, $\boldsymbol{R_{mid}}$ and $\boldsymbol{R_{low}}$, respectively. The portfolios are rebalanced at the end of June for $t+1$. The three portfolios will be used as dependent variables in Equation (5.1) to examine heterogeneous risk exposure based on book-to-market ratio.

Similar to Chapter 4 (Section 4.2.4), to ensure the accounting variables predate the returns they are used to explain, the accounting data for fiscal year $t-1$ are matched with the returns for July of year t to June of $t+1$ (Fama and French, 1992). As discussed in Section 4.2.4, this six month lag is based on research by Alford et al. (1994) and Conover et al. (2008) regarding the lag between the fiscal year end and the publication of annual reports.

To form the three momentum portfolios, the average excess return for all 88 European energy utilities is calculated daily over the formation period from day $t-251$ to day $t-21$ and excludes the sort month. To be considered as an upper momentum utility, the energy stock's returns during the formation period and on $t-21$ must be positive; similarly, the stock returns during the formation period and return on $t-21$ must be negative for down momentum utilities. The $t-21$ condition ensures that the upper and down momentums continue until the end of the formation period and reversal has not already begun. The daily break points are defined as the top 30% (upper momentum), the middle 40% (medium momentum) and the bottom 30% (down momentum). The value-weighted daily returns on the upper, medium and down momentum portfolios are calculated, rebalanced daily, and denoted $\boldsymbol{R_{upper}}$, $\boldsymbol{R_{medium}}$ and $\boldsymbol{R_{down}}$, respectively. The $\boldsymbol{R_{upper}}$, $\boldsymbol{R_{medium}}$ and $\boldsymbol{R_{down}}$ portfolios will be used as dependent variables in Equation (5.1) to identify whether the risk factors for energy utilities differ based on momentum. Based on Moskowitz and Grinblatt (1999), Boni and Womack (2006) and Fama and French (2012), the three momentum portfolios are expected, by definition, to have extreme momentum tilt and thus the local AFFM may have difficulty capturing average returns. This issue is addressed in Section 5.4.2.1.

To form the three industry portfolios, up to 10 SICs for each energy utility are obtained, annually, between 1996 and 2013.[53] The SIC system is designed to categorise industries[54] using a four-digit code, where the former digits represent the major sectors to which a firm belongs, while the latter digits represent industries and sub-classifications (operations) within industries. The SIC groupings are similar to that employed by Moskowitz and Grinblatt (1999), who use a two-digit classification system. When multiple SICs are available, the SICs are ranked from most important source of revenue to least important.

The SICs of each utility are categorised, annually, as: electricity industry, natural gas industry, multi-utility industry, or ‘other’ operations – denoting any operation outside of the energy sector. The categories are based on SIC descriptions,[55] shown in Table 5.1. Due to lack of detail in the SIC system, it is not possible to further delineate the electricity industry into generation, transmission and/or distribution operations. Therefore, the analysis is restricted at the industry level rather than the operation level. Some utilities contained secondary operations outside of the energy sector and ancillary operations beyond the primary source of revenue, for example, electricity line maintenance. As these are auxiliary operations, they are not expected to significantly impact returns.

---

[53] Due to the significant data omissions for 2014, 2013 was the most comprehensive end date possible and therefore also determined the end date of the analysis.

[54] There are various definitions for sector, industry and operations. For example, see the conflict between the Global Industry Classification Standard, the Industry Classification Benchmark and Standard Industrial Classification (which only includes industry). For clarity, it is important to distinguish between the definitions of sector, industry and operation for this thesis as the three are often used interchangeably when, in fact, differences exist. This thesis defines sector as a large segment of the economy, for example, the energy sector. Industry describes a more specific group of companies within the sector with similar activities, for example, the electricity, natural gas and multi-utility industries. Operation describes even more detailed processes within the industry: for example, electricity generation, electricity transmission and electricity distribution.

[55] Descriptions can be found at: http://siccode.com/en/siccode/list/directory

TABLE 5.1: SIC CODES, INDUSTRY AND OPERATIONS

This table presents the SIC codes used to classify the 88 European energy utilities into three portfolios based on industry: electricity, natural gas and multi-utility.

Industry	SIC	Operation
Electricity	4910	Electric Services
	4911	Electric Services
	4931	Electric and other Services Combined
Natural Gas	1311	Crude Petroleum and Natural Gas
	1321	Natural Gas Liquids
	1382	Oil and Gas Field Exploration Services
	1389	Oil and Gas Field Services, not elsewhere classified
	2813	Industrial Gases
	2911	Petroleum Refining
	4920	Gas Production and Distribution
	4922	Natural Gas Transmission
	4923	Natural Gas Transmission and Distribution
	4924	Natural Gas Distribution
	4925	Mixed, Manufactured, or Liquefied Petroleum Gas Production and/or Distribution
	4932	Gas and other Services Combined
	5172	Petroleum and Petroleum Products Wholesalers, except Bulk Stations and Terminals
Multi-Utility	4900	Electric, Gas and Sanitary Services
	4939	Combination Utilities, not elsewhere classified

Based on the SICs, utilities categorised within the electricity industry exclusively contain electricity operations and ‘other’ operations, the natural gas industry exclusively contain natural gas operations and ‘other’ operations, while the multi-utility industry is identified by its SIC or contains operations from both the electricity and natural gas industries. The natural gas industry contained some operations which overlap with the oil and petroleum industry. The natural gas industry may show some similarities to the oil & gas sector results in Chapter 4 (see related discussion in Section 3.2.3.3 and results in Table 4.5).

As SIC codes define the business operations which generate the highest revenue for the firm in the past year (t), SIC codes for year t are matched[56] to returns for July of year t to June of $t+1$. The value-weighted daily returns on the electricity, natural gas and multi-utility portfolios are calculated, denoted $\boldsymbol{R_{elecutil}}$, $\boldsymbol{R_{gasutil}}$ and $\boldsymbol{R_{multi}}$, respectively. The portfolios are rebalanced annually in June of year $t+1$ to control for utilities which change operations or industries. This is an improvement over Oberndorfer (2009a) and Koch and Bassen (2013), who do not rebalance portfolios. This could be a major issue in the case of company mergers, where the acquiring firm shifts operations from, say, electricity to multi-utility operations. Although rare, some of the SICs of utilities changed across years, but were mostly confined to ancillary operations rather than primary operations. The rebalancing will also assist in Chapter 6 of the thesis when measuring the sensitivity of an industry to a new regulatory change, ensuring that the industry portfolios are correctly categorised. The $\boldsymbol{R_{elecutil}}$, $\boldsymbol{R_{gasutil}}$ and

---

[56] Matching SICs of year $t-1$ to returns of year t only made minor differences to the cumulative returns of the natural gas and multi-utility portfolios. The overall trend of the three portfolios did not change.

$\boldsymbol{R_{multi}}$ portfolios will be used as dependent variables in Equation (5.1) to identify the heterogeneous risk exposure of energy utilities based on industry.

As noted in this section and Sections 5.3.1, the 12 portfolios defined above will be used as dependent variables for analysis in Equation (5.1), where $\boldsymbol{R_{i,t}} \equiv \boldsymbol{R_{util,t}}$, $\boldsymbol{R_{small,t}}$, $\boldsymbol{R_{big,t}}$, $\boldsymbol{R_{high,t}}$, $\boldsymbol{R_{mid,t}}$, $\boldsymbol{R_{low,t}}$, $\boldsymbol{R_{upper,t}}$, $\boldsymbol{R_{medium,t}}$, $\boldsymbol{R_{down,t}}$, $\boldsymbol{R_{elecutil,t}}$, $\boldsymbol{R_{gasutil,t}}$ or $\boldsymbol{R_{multi,t}}$. Each portfolio will be regressed independently. The following section explains the construction of the local stock market risk factors used as independent variables in Equation (5.1).

5.3.3 The Local Stock Market Risk Factors: Size, Value and Momentum Premia

For the independent variables, local stock market risk factors are calculated in a similar manner to global factors in Chapter 4. While Chapter 4 uses a diversified portfolio of 600 European stocks (see Section 4.2.4) to create the global stock market risk factors, this chapter only uses the 88 European energy utilities to create the local stock market risk factors. As stated in the chapter's introduction (Section 5.1), the use of local stock market risk factors is expected to improve regression fit and is necessary to examine within-sector heterogeneity. The sector level mimicking portfolios are used as explanatory variables on the RHS of this chapter's regression models (see Section 5.3.1). The method to construct the variables is outlined extensively in Section 4.2.4, the following paragraphs present definitions and interpretations of the local stock market risk factors for interpretation of forthcoming results.

The local SMB (small minus big) risk factor ($LSMB_t$) mimics the risk factor in returns which is related to energy utility firm size, representing local size premium. The $LSMB_t$ represents a zero sum investment which is long on small energy utilities and short on big energy utilities. Small energy utilities are expected to generate higher returns than big energy utilities. A positive (negative) $LSMB_t$ factor in Figure 5.4 and Table 5.2 indicates that small energy utilities outperform (underperform) big energy utilities. A positive (negative) s_i coefficient in Table 5.5 indicates that the energy portfolio of interest behaves like small (big) energy utilities.

The local HML (high minus low) risk factor ($LHML_t$) mimics the risk factor in returns which is related to energy utility book-to-market ratio. The $LHML_t$ represents a zero sum investment which is long on high-BE/ME (value) energy utilities and short on low-BE/ME (growth) energy utilities, representing local value premium. High-BE/ME utilities are expected to generate higher returns than low-BE/ME utilities. A positive (negative) $LHML_t$ factor in Figure 5.4 and Table 5.2 indicates that high-BE/ME energy utilities outperform (underperform) low-BE/ME energy utilities stocks. A positive (negative) h_i coefficient in

Table 5.5 indicates that the energy portfolio of interest behaves like high-BE/ME (low-BE/ME) energy utilities.

The local UMD (upper minus down) risk factor ($LUMD_t$) mimics the risk factor in returns which is related to energy utility persistence of earnings (momentum). The $LUMD_t$ represents a zero sum investment which is long on upper momentum energy utilities and short on down momentum energy utilities and represents the momentum premium. Upper momentum energy utilities are expected to generate higher returns than down momentum energy utilities. A positive (negative) $LUMD_t$ factor in Figure 5.4 and Table 5.2 indicates that upper momentum energy utilities outperform (underperform) down momentum energy utilities stocks. A positive (negative) m_i coefficient in Table 5.5 indicates that the energy portfolio of interest behaves like upper momentum (down momentum) energy utilities.

5.4 Results

This chapter explores the four analytical foci outlined in Section 5.1, namely: 1) refining the AFFM to produce the local AFFM, 2) examining within-sector heterogeneity across sub-groups of European energy utilities, 3) applying inductive structural break point tests and 4) better isolating the firm-specific component of returns.

The following results section is structured as follows. Section 5.4.1 presents the descriptive results of this chapter. Within the descriptive results, Section 5.4.1.1 presents the return profiles of the 12 energy utility portfolios (outlined previously in Section 5.3.2.1) and risk factors for context, while Section 5.4.1.2 reports the summary statistics of the data. Section 5.4.2 presents the econometric results for this chapter. Within the econometric results, Section 5.4.2.1 presents the results of the local AFFM for the energy utility sector as a whole, addressing the first analytical focus. The local AFFM is also implemented on the 12 energy portfolios to examine within-sector heterogeneity, addressing the 2nd analytical focus. For completeness and comparability across chapters, Section 5.4.2.1 also reports the results of the three alternative asset pricing models (CAPM, augmented-CAPM and local four-factor model), while Section 5.4.2.2 reports the inter-temporal regressions using the local AFFM. To address analytical focus 3, Section 5.4.2.3 reports the Bai and Perron (1998; 2003) inductive structural break point test. Finally, Section 5.4.2.4 addresses analytical focus 4 by outlining a method to better isolate the firm-specific component of returns from the residuals of the asset pricing models.

5.4.1 Descriptive Results

5.4.1.1 Return profiles of energy utilities and risk factors

The results section begins with a description of the return profiles of the 12 energy utility portfolios constructed in Section 5.3.2.1. The cumulative returns of all 12 energy portfolios can be observed in Figure 5.2. The daily returns, used in empirical analysis, can also be observed in Figure 5.3. For both cumulative returns and daily returns, the observations are calculated between 01 July 1996 and 28 June 2013.

Figure 5.2 (Plot A) compares the cumulative returns for the energy sector and the two size portfolios: small and big energy utilities. As expected, the small energy utilities have higher cumulative returns than the large energy utilities, illustrating a clear size effect. As argued in Section 3.2.2.1, small utilities are expected to generate higher returns than larger utilities due to additional risk exposure and from the effect of being marginal firms (Banz, 1981, Chan et al., 1985, Chan and Chen, 1991). The cumulative returns of the big energy utilities are barely indistinguishable from the sector. Section 5.3.2.1 showed that big energy utilities account for 96.3% of total sector valuation; their large market capitalisations have a greater influence on overall sector returns.[57] An implication of this result is that any inference regarding impacts on energy sector valuation as a whole are implicitly discussing the impact on big utilities' valuation. Small utilities are obscured at sector level, have less contribution to overall sector valuation and have a unique return profile.

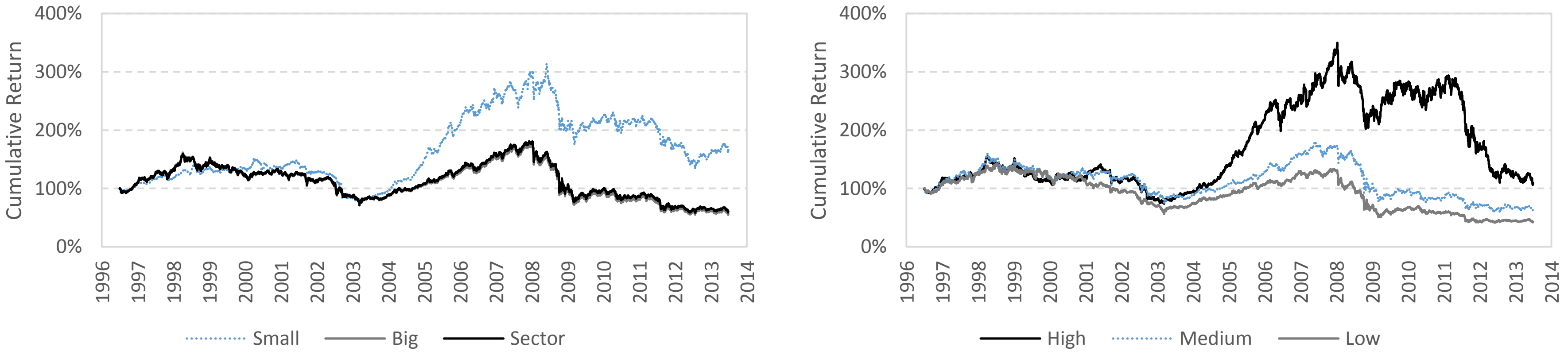
Plot B of Figure 5.2 shows the cumulative return profiles for the three BE/ME portfolios. The high-BE/ME (value) energy utilities have higher cumulative returns than mid-BE/ME (neutral) energy utilities, and low-BE/ME (growth) energy utilities have the lowest cumulative returns overall. The cumulative returns are consistent with the literature in Section 3.2.2.2; high-BE/ME utilities are expected to outperform low-BE/ME utilities (Rosenberg et al., 1985, Chan et al., 1991, Fama and French, 1992, 1993, 1995, 1998). The value premium is often criticised for being an empirically determined variable, but the literature in Section 3.2.2.3 argues that high-BE/ME companies are riskier, less profitable and often have characteristics consistent with firm distress, requiring greater return on investment (Chan et al., 1991, Fama and French, 1995, 1996). Regardless, a large value premium is observed in the energy utility sector.

---

[57] Section 3.3.5.1 argued that value-weighted portfolios are preferable as they represent realistic investment opportunities (Fama and French, 1993).

(A) Sector and Two Size Portfolios

(B) Three Book-to-Market Portfolios



(C) Three Momentum Portfolios

(D) Three Industry Portfolios

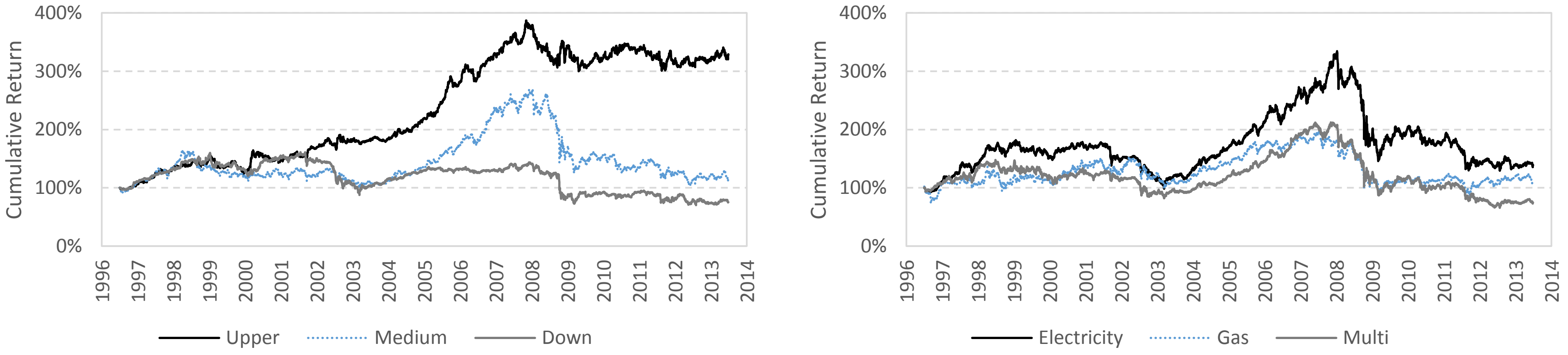


FIGURE 5.2: CUMULATIVE RETURN FOR THE 12 ENERGY PORTFOLIOS.

This figure presents the cumulative return profile of the 12 energy utility portfolios constructed in Section 5.3.2.1. Plot A contains the whole energy sector, small utilities and big utilities. Plot B contains the three portfolios formed on book-to-market: high-, mid- and low-BE/ME. The portfolios represent value, nautral and growth stocks, respectively. Plot C contains the three momentum portfolios: upper, medium and down momentum. Plot D contains the three industry portfolios: electricity- natural gas- and multi-utility. Cumulative returns are calculated based on daily returns outlined in Figure 5.3.

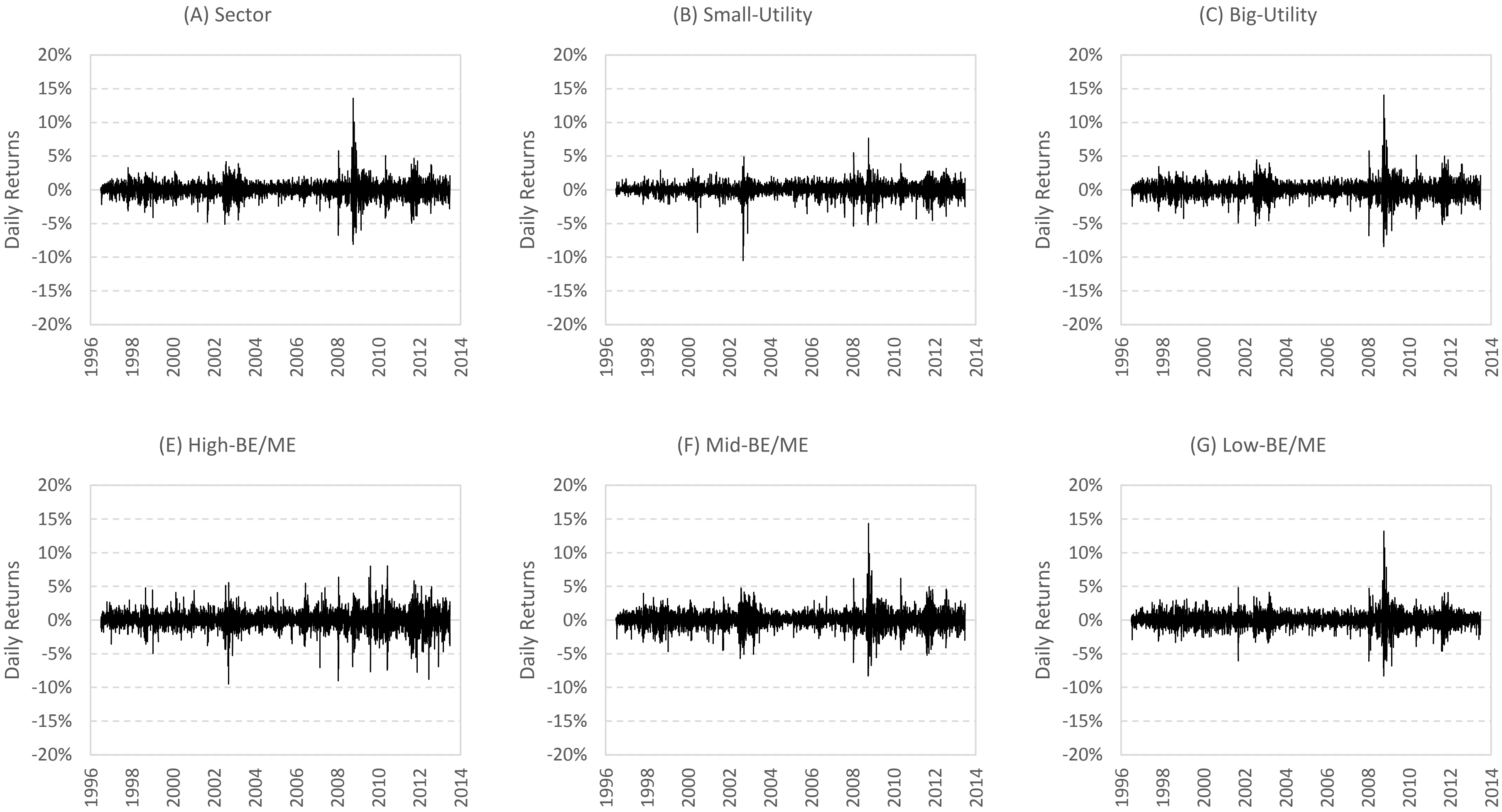


FIGURE 5.3: DAILY RETURN SERIES FOR THE 12 ENERGY PORTFOLIOS

This figure, illustrated across two pages, presents the daily return profiles of the 12 energy utility portfolios constructed in Section 5.3.2.1. Daily returns are calculated as first-log difference.

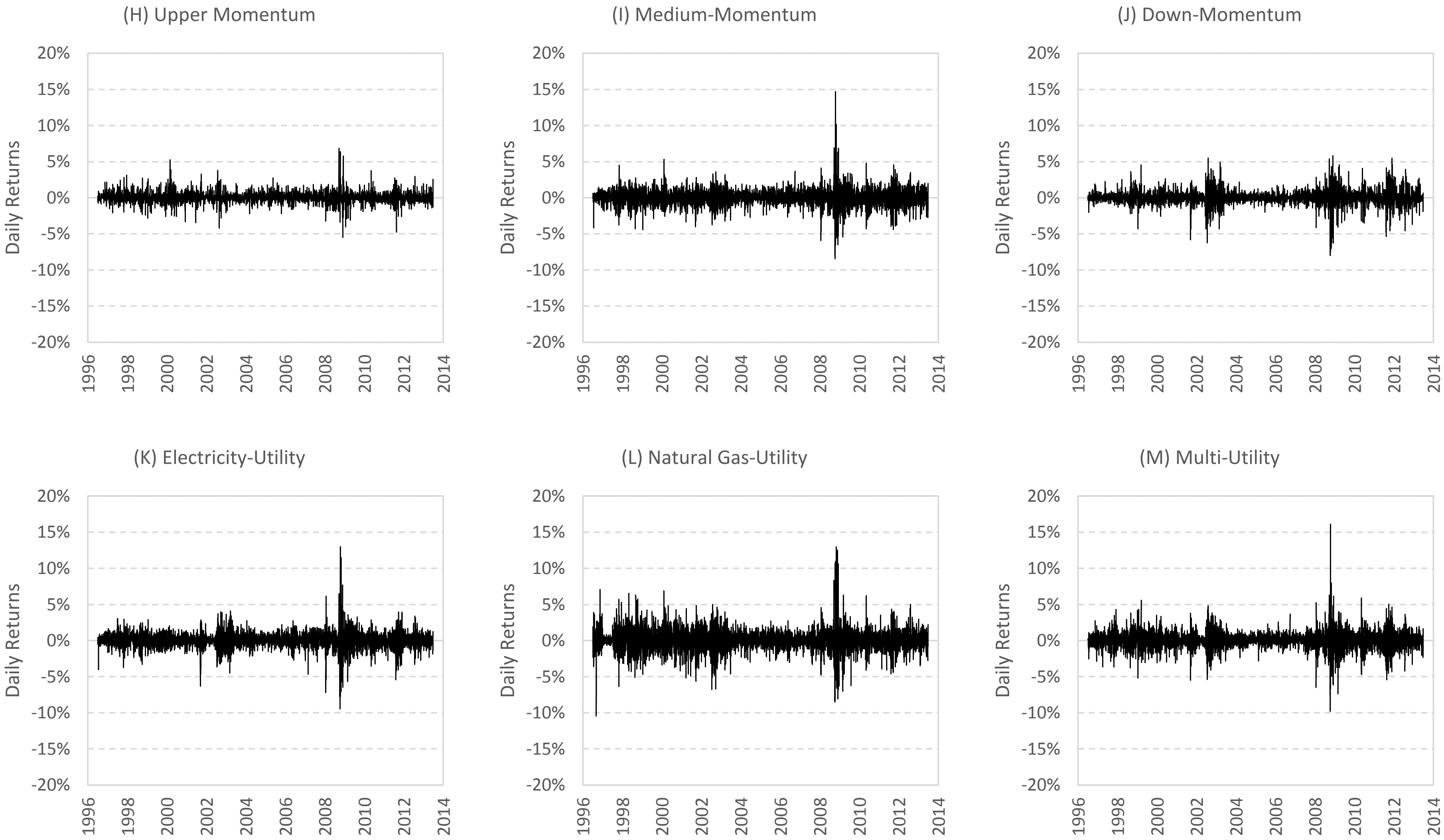
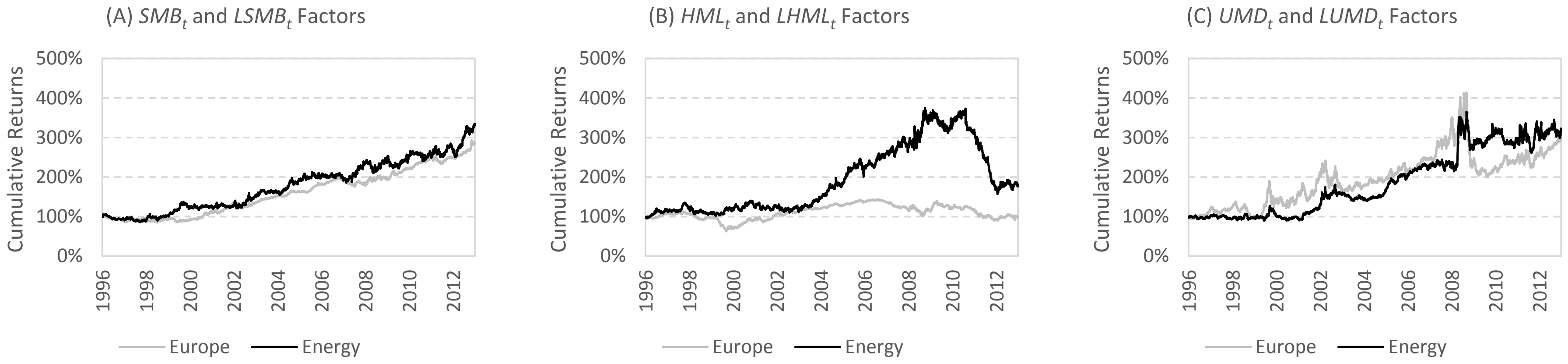


FIGURE 5.3 (CONTINUED)

Plot C of Figure 5.2 illustrates the cumulative returns for the three momentum portfolios. Naturally, the upper momentum portfolio dramatically outperforms the medium and down momentum portfolios. Interestingly, there is almost no difference in the three momentum portfolios until 2000, when the portfolios begin to diverge. This date occurs soon after the first packages of liberalisation. Momentum may only exist in liberalised markets with competition. This is a logical inference, as Section 2.2 argued that the previously regulated energy markets contained vertically integrated utilities with natural, regional monopolies, preventing any competition. Utilities could not gain or lose market share to competitors; thus, profitability would have been tied to the surrounding population's energy consumption which is assumed to be relatively inelastic (see Oberndorfer, 2009a). As isolated markets and unfair grid access is still a major concern of liberalisation objectives in Section 2.2.1, we expect momentum premium shifts surrounding these legislation.

Finally, Plot D of Figure 5.2 presents the cumulative returns for the three industry portfolios. The results show that the electricity utility portfolio generated the greatest cumulative returns across time, indicating a higher risk-return relationship. In contrast, the natural gas and multi-utility portfolios show similar returns through time. The multi-utilities showed one of the lowest cumulative abnormal returns across all portfolios – possibly indicating a lower risk-return relationship. This is consistent with economy of scope, where multi-utilities provide customers in the same region with electricity, gas and other services such as waste and water. A diversified portfolio of operations is less likely to be exposed to the regulatory and operational risks of single utilities. Further, if a regulation is found to negatively impact one operation or industry, for example, electricity generation, the multi-utility can shift costs from the affected operation to the more profitable operation or industry. The variety of services result in a less risky revenue stream; therefore, investors will require lower return on investment. The risk exposure of each industry portfolio will be addressed in Section Table 5.5 to address this proposition.

The market factor, term premium and commodity risk factors were covered extensively in Section 4.3.1, and are, therefore, not outlined here for brevity. Instead, the following paragraphs provide a discussion of the returns associated with the local stock market risk factors: $LSMB_t$, $LHML_t$ and $LUMD_t$. For comparison, Figure 5.4 compares the local stock market risk factors of this chapter with the global stock market risk factors of Chapter 4 (Figure 4.3, Plots A, B and C).

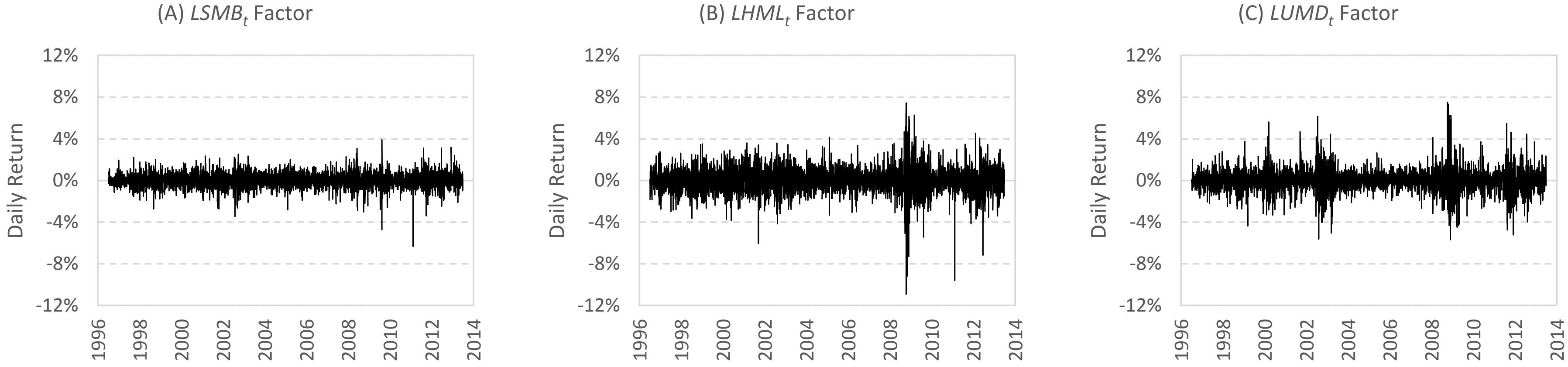

(A) SMB_t and $LSMB_t$ Factors

(B) HML_t and $LHML_t$ Factors

(C) UMD_t and $LUMD_t$ Factors

FIGURE 5.4: COMPARISON OF CUMULATIVE RETURNS FOR GLOBAL AND LOCAL STOCK MARKET RISK FACTORS

This figure presents the cumulative returns of the three stock market risk factors in Chapters 4 and 5: the size, value and momentum premia. The black line represents local stock market risk factors of Chapter 5, specific to energy utilities, including $LSMB_t$, $LHML_t$ and $LUMD_t$. The grey line represents global stock market risk factors of Chapter 4, for European stocks generally, including SMB_t, HML_t and UMD_t.


(A) $LSMB_t$ Factor

(B) $LHML_t$ Factor

(C) $LUMD_t$ Factor

FIGURE 5.5: DAILY RETURNS FOR THE LOCAL STOCK MARKET RISK FACTORS

This figure presents the daily returns of the three local stock market risk factors for Chapter 5 only, including: the size, value and momentum-premia.

First, Figure 5.4 (Plot A) shows the SMB factors are relatively consistent between the two chapters. The positive local SMB factor ($LSMB_t$) shows that there is a constant spread in returns between the small and big energy utilities. Further, Figure 5.5 (Plot A) shows no major changes in returns around the dot-com bubble, GFC or EUC. Plot B of Figure 5.4 shows that the local HML factor ($LHML_t$) is far more prominent than the global HML factor (HML_t). There is relatively little difference between the two value premia until 2003, when the local HML factor shows that high-BE/ME (value) energy utilities dramatically outperform low-BE/ME (growth) energy utilities. This divergence coincides with the second packages of liberalisation (see Section 2.2.1). Post 2009, there is a large shift in value premium, where the negative HML factor shows that low-BE/ME energy utilities begin to outperform high-BE/ME. This occurs post-GFC and around the third packages of liberalisation, possibly indicating that relatively distressed (high-BE/ME) utilities performed poorly and growth firms dominate sector returns. Plot B of Figure 5.5 shows that the impact of the GFC is also evident in the daily returns of the local HML factor. Finally, Plot C of Figure 5.4 shows that the local UMD factor for energy utilities ($LUMD_t$) behaves similar to the global UMD factor for European stocks (UMD_t). Plot C of Figure 5.5 show some clustering of volatility across time, with the major clustering occurring in 2003 and 2009, the locations of the second and third packages of liberalisation (see Section 2.2.1 and Table 2.1).

The important implications for the results above are that the local and global stock market risk factors differ. While the SMB and UMD risk factors are similar between chapters, the cumulative return profiles are not identical. The results of Table 5.5 will show that this has some impact on the estimated SMB and UMD coefficients. Further, the HML factors are dramatically different between the two chapters. Importantly, the use of global stock market risk factors would obscure the true underlying (local) HML factor for energy utilities. The results in Table 5.5 will show that this has major implications on the estimated coefficients. Superficially, there is some support for analytical focus 1, that the AFFM can be refined by calculating local stock market risk factors.

5.4.1.2 Summary statistics

The summary statistics for all 12 portfolios and nine risk factors are presented in Table 5.2. Most of the returns across all portfolios and risk factors are not statistically different from zero, with the exception of upper momentum utilities, the $LHML_t$ risk factor, $LUMD_t$ risk factor, term premium and carbon risk. The summary statistics indicate that the mean daily return for the energy sector is -0.0051%, losing value over time. Small utilities achieve a greater mean return (0.0155%) compared with big utilities (-0.0062%), reflecting the greater risk-return relationship of small utilities. Big utilities lose value over time. Regarding book-to-market portfolios, high-BE/ME utilities achieve greater mean returns (0.0102%) compared with mid- and low-BE/ME utilities (-0.0027% and -0.0131%, respectively). For momentum portfolios, the upper momentum portfolio achieves a mean return of 0.0291%, significant at $p \leq 0.01$ and greater than the medium and down momentum portfolios (0.0095% and -0.0022%, respectively). When categorising portfolios by operations, the electricity and natural gas industries achieve mean returns of 0.0136% and 0.0127%, respectively. Multi-utilities only achieved a mean return of 0.0006%, consistent with the lower perceived risk and economy of scope argument presented above.

The market factor, term premium, oil, coal, natural gas and carbon were addressed previously in Section 4.3.1.2 (Table 4.2), the summary statistics for these risk factors remain unchanged. The following paragraph addresses the local stock market risk factors, which produce differing results in comparison with Table 4.2.

Regarding the risk factors, the $LSMB_t$ factor shows there is a significant spread in daily returns of 0.0309% ($p = 0.015$) between small and big energy utilities. The $LSMB_t$ factor is marginally greater than the global SMB_t of Table 4.2 (0.0252%, $p \leq 0.01$). The return spread is interesting in its own right, as the energy sector was heavily dominated by big utilities until 2003. When big utilities were unbundled and pan-European competition was introduced, small utilities could begin to take market share and expand into previously dominated markets. The significant size premium is consistent with Fama and French (1993, 1995, 1997, 2012). The $LHML_t$ factor shows a daily premium of 0.0184% for high-BE/ME (value) energy utilities compared with low-BE/ME (growth) energy utilities. This result contrasts the insignificant global HML_t factor of Table 4.2. As posited in Section 5.4.1.1, energy utilities have a greater value premium than most European stocks. The $LUMD_t$ factor shows daily return spread of 0.0313% ($p = 0.041$) between upper and down momentum utilities. The $LUMD_t$ factor is near identical to the UMD_t presented in Table 4.2 (0.0312%, $p \leq$0.05). As stated in Section 5.4.1.1, the differences between the local and global stock market risk factors lend some support to analytical focus 1, the existence of sector level peculiarities, suggesting the local stock market risk factors may have a better goodness of fit in the AFFM specification.

TABLE 5.2: SUMMARY STATISTICS FOR THE PORTFOLIOS AND RISK FACTORS

Summary statistics for the 12 portfolios and nine risk factors, including: number of daily observations (N), mean daily return, t-statistic of the mean, annualised mean return, standard deviation, minimum observation, maximum observation, skewness, kurtosis, mean market capitalisation, mean book value of equity and book-to-market ratio. The t-mean statistic is the ratio of the mean daily return to its standard error. The 12 value-weighted portfolios include: the energy sector ($\boldsymbol{R_{util,t}}$), high-BE/ME utilities ($\boldsymbol{R_{high,t}}$), mid-BE/ME utilities ($\boldsymbol{R_{mid,t}}$), low-BE/ME utilities ($\boldsymbol{R_{low,t}}$), upper momentum utilities ($\boldsymbol{R_{upper,t}}$), medium momentum utilities ($\boldsymbol{R_{medium,t}}$), down momentum utilities ($\boldsymbol{R_{down,t}}$), electricity utilities ($\boldsymbol{R_{elecutil,t}}$), natural gas utilities ($\boldsymbol{R_{gasutil,t}}$), multi-utilities ($\boldsymbol{R_{multi,t}}$), small utilities ($\boldsymbol{R_{small,t}}$) and big utilities ($\boldsymbol{R_{big,t}}$). The nine risk factors include: the market factor ($\boldsymbol{R_{m,t}}$), local size premium ($LSMB_t$), local value premium ($LHML_t$), local momentum premium ($LUMD_t$) term premium ($\boldsymbol{R_{tp,t}}$), oil risk ($R_{o,t}$), coal risk ($R_{c,t}$), gas risk ($R_{g,t}$) and carbon risk ($R_{co2,t}$). Mean market capitalisation and book value of equity are calculated across all years for each portfolio, shown in €millions. A ****, ***, ** or * denotes significance at 0.1%, 1%, 5% or 10%, respectively.

	$\boldsymbol{R_{util,t}}$	$\boldsymbol{R_{high,t}}$	$\boldsymbol{R_{mid,t}}$	$\boldsymbol{R_{low,t}}$	$\boldsymbol{R_{upper,t}}$	$\boldsymbol{R_{medium,t}}$	$\boldsymbol{R_{down,t}}$	$\boldsymbol{R_{elecutil,t}}$	$\boldsymbol{R_{gasutil,t}}$	$\boldsymbol{R_{multi,t}}$	$\boldsymbol{R_{small,t}}$
N	4435	4435	4435	4435	4435	4435	4435	4435	4435	4435	4435
Mean	-0.0051%	0.0102%	-0.0027%	-0.0131%	0.0291%	0.0095%	-0.0022%	0.0136%	0.0127%	0.0006%	0.0155%
***t*-Mean**	(-0.30)	(0.53)	(-0.15)	(-0.80)	(2.85)***	(0.56)	(-0.16)	(0.81)	(0.58)	(0.03)	(1.12)
Std. Dev. Daily	1.11%	1.29%	1.23%	1.09%	0.67%	1.14%	0.90%	1.10%	1.49%	1.20%	0.89%
Mean Annualised	-1.32%	2.69%	-0.70%	-3.35%	7.86%	2.50%	-0.57%	3.60%	3.36%	0.16%	4.11%
Min	-8.10%	-9.53%	-8.29%	-8.34%	-5.48%	-8.46%	-7.98%	-9.49%	-10.48%	-9.80%	-10.53%
Max	13.60%	8.04%	14.38%	13.22%	6.85%	14.70%	5.83%	13.00%	12.96%	16.13%	7.71%
Skew	0.09	-0.43	0.15	0.11	0.53	0.24	-0.58	0.03	0.20	0.20	-0.86
Kurt	14.80	8.85	12.93	15.03	14.70	15.49	14.63	16.51	10.18	15.68	14.36
Mean Market Cap.	7,869.25	3,383.21	12,722.44	11,599.21	7,318.08	11,553.89	9,208.67	6,381.02	14,954.77	13,489.90	1,201.88
Mean Book Value	5,134.55	3,831.36	7,482.48	3,661.81	3,730.04	6,315.23	5,253.09	6,469.90	2,747.28	2,693.20	1,046.02
Book-to-Market Ratio	0.65	1.13	0.59	0.32	0.51	0.55	0.57	1.01	0.18	0.20	0.87

	$\boldsymbol{R_{big,t}}$	$\boldsymbol{R_{m,t}}$	$LSMB_t$	$LHML_t$	$LUMD_t$	$\boldsymbol{R_{tp,t}}$	$R_{o,t}$	$R_{c,t}$	$R_{g,t}$	$R_{co2,t}$
N	4435	4435	4435	4435	4435	4435	4435	4435	4435	2135
Mean	-0.0062%	0.0036%	0.0309%	0.0184%	0.0313%	0.0262%	0.0383%	0.0158%	0.0424%	-0.4233%
***t*-Mean**	(-0.36)	(0.19)	(2.50)**	(1.18)	(2.04)**	(7.90)****	(1.32)	(0.78)	(0.74)	(-2.64)***
Std. Dev. Daily	1.15%	1.26%	0.85%	1.06%	1.01%	0.16%	1.78%	1.36%	3.73%	7.42%
Mean Annualised	-1.60%	0.94%	8.35%	4.91%	8.48%	7.05%	10.47%	4.19%	11.65%	-66.81%
Min	-8.45%	-7.94%	-6.46%	-9.42%	-5.68%	-0.71%	-11.35%	-16.08%	-28.13%	-138.63%
Max	14.09%	9.40%	4.94%	8.00%	7.49%	0.36%	12.56%	19.78%	47.77%	109.86%
Skew	0.12	-0.17	-0.13	-0.15	0.43	-1.06	-0.27	0.80	2.58	-3.14
Kurt	15.06	7.96	5.71	9.07	10.19	4.74	6.17	38.75	28.85	121.76
Mean Market Cap.	17,696.09									
Mean Book Value	9,266.01									
Book-to-Market Ratio	0.52									

The following paragraphs outline the preliminary statistics addressing standard assumptions of a linear regressions. First, similar to Section 4.3.1.2, Augmented Dickey-Fuller (1979) (ADF) unit root tests were implemented to confirm the stationarity of the time series, ensuring the dependent and independent variables were integrated to the same order and that a linear relationship can exist between the variables. The results of the ADF test, shown in Table 5.3, confirm that the time series is integrated to order zero, $I(0)$, and stationary.

TABLE 5.3: AUGMENTED DICKEY-FULLER TESTS

This table presents the results of the ADF test for unit roots. The null hypothesis is that the variable contains a unit root, against the alternative of no unit root (stationarity). A ***, ** or * denotes 1%, 5% or 10% significance, respectively. The ADF test does not report significance greater than 1%.

Variable	ADF Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value	Sig.
$\boldsymbol{R_{util,t}}$	-66.04	-3.43	-2.86	-2.57	***
$\boldsymbol{R_{high,t}}$	-67.55	-3.43	-2.86	-2.57	***
$\boldsymbol{R_{mid,t}}$	-66.93	-3.43	-2.86	-2.57	***
$\boldsymbol{R_{low,t}}$	-65.79	-3.43	-2.86	-2.57	***
$\boldsymbol{R_{upper,t}}$	-65.30	-3.43	-2.86	-2.57	***
$\boldsymbol{R_{medium,t}}$	-67.51	-3.43	-2.86	-2.57	***
$\boldsymbol{R_{down,t}}$	-63.20	-3.43	-2.86	-2.57	***
$\boldsymbol{R_{elecutil,t}}$	-64.42	-3.43	-2.86	-2.57	***
$\boldsymbol{R_{gasutil,t}}$	-70.44	-3.43	-2.86	-2.57	***
$\boldsymbol{R_{multi,t}}$	-64.56	-3.43	-2.86	-2.57	***
$\boldsymbol{R_{small,t}}$	-62.49	-3.43	-2.86	-2.57	***
$\boldsymbol{R_{big,t}}$	-66.23	-3.43	-2.86	-2.57	***
$\boldsymbol{R_{m,t}}$	-66.21	-3.43	-2.86	-2.57	***
$LSMB_t$	-70.73	-3.43	-2.86	-2.57	***
$LHML_t$	-68.55	-3.43	-2.86	-2.57	***
$LUMD_t$	-65.11	-3.43	-2.86	-2.57	***
$\boldsymbol{R_{tp,t}}$	-7.73	-3.43	-2.86	-2.57	***
$R_{o,t}$	-55.95	-3.43	-2.86	-2.57	***
$R_{c,t}$	-66.76	-3.43	-2.86	-2.57	***
$R_{g,t}$	-63.62	-3.43	-2.86	-2.57	***
$R_{co2,t}$	-47.63	-3.43	-2.86	-2.57	***

Second, Table 5.4 presents the pairwise correlations between all portfolios and risk factors, with corresponding significance tests. The energy portfolios, are included as they the correlations will be useful for interpretations in 5.4.2. For the 12 energy portfolios, the most prominent observation is the high correlation between the energy sector and big utilities. As recent as 2015, a small number of energy giants still dominate the energy sector, colloquially known as the ‘big six’ energy suppliers. Also, the portfolio formation in Section 5.3.2.1 highlighted that big utilities accounted for the majority of sector market capitalisation. The correlations also suggest that returns in the low- and mid-BE/ME portfolios show higher correlation with the energy sector than the high-BE/ME portfolio. The medium momentum, electricity- and multi-utility portfolios also show higher correlation with the energy sector. These sectors typically have higher market capitalisation than other energy portfolios.

TABLE 5.4: PAIRWISE CORRELATIONS BETWEEN PORTFOLIOS AND RISK FACTORS

This table presents pairwise correlations between the 12 portfolios and eight risk factors. The 12 value-weighted portfolios include: the energy sector ($\boldsymbol{R_{util,t}}$), small utilities ($\boldsymbol{R_{small,t}}$), big utilities ($\boldsymbol{R_{big,t}}$), low-BE/ME utilities ($\boldsymbol{R_{low,t}}$), mid-BE/ME utilities ($\boldsymbol{R_{mid,t}}$), high-BE/ME utilities ($\boldsymbol{R_{high,t}}$), upper momentum utilities ($\boldsymbol{R_{upper,t}}$), medium momentum utilities ($\boldsymbol{R_{medium,t}}$), down momentum utilities ($\boldsymbol{R_{down,t}}$), electricity utilities ($\boldsymbol{R_{elecutil,t}}$), natural gas utilities ($\boldsymbol{R_{gasutil,t}}$) and multi-utilities ($\boldsymbol{R_{multi,t}}$). The nine risk factors include: market premium ($\boldsymbol{R_{m,t}}$), local size premium ($LSMB_t$), local value premium ($LHML_t$), local momentum premium ($LUMD_t$) term premium ($\boldsymbol{R_{tp,t}}$), oil price risk ($R_{o,t}$), coal price risk ($R_{c,t}$), natural gas price risk ($R_{g,t}$) and carbon price risk ($R_{co2,t}$). A ****, ***, ** or * denotes significance at 0.1%, 1%, 5% or 10%, respectively.

	Dependent Variables												Independent Variables								
	$\boldsymbol{R_{util,t}}$	$\boldsymbol{R_{high,t}}$	$\boldsymbol{R_{mid,t}}$	$\boldsymbol{R_{low,t}}$	$\boldsymbol{R_{upper,t}}$	$\boldsymbol{R_{medium,t}}$	$\boldsymbol{R_{down,t}}$	$\boldsymbol{R_{elecutil,t}}$	$\boldsymbol{R_{gasutil,t}}$	$\boldsymbol{R_{multi,t}}$	$\boldsymbol{R_{small,t}}$	$\boldsymbol{R_{big,t}}$	$\boldsymbol{R_{m,t}}$	$LSMB_t$	$LHML_t$	$LUMD_t$	$\boldsymbol{R_{tp,t}}$	$R_{o,t}$	$R_{c,t}$	$R_{g,t}$	$R_{co2,t}$
$\boldsymbol{R_{util,t}}$	1.000																				
$\boldsymbol{R_{high,t}}$	0.605 ****	1.000																			
$\boldsymbol{R_{mid,t}}$	0.968 ****	0.541 ****	1.000																		
$\boldsymbol{R_{low,t}}$	0.884 ****	0.476 ****	0.767 ****	1.000																	
$\boldsymbol{R_{upper,t}}$	0.543 ****	0.351 ****	0.523 ****	0.469 ****	1.000																
$\boldsymbol{R_{medium,t}}$	0.927 ****	0.573 ****	0.905 ****	0.815 ****	0.457 ****	1.000															
$\boldsymbol{R_{down,t}}$	0.718 ****	0.430 ****	0.686 ****	0.658 ****	0.209 ****	0.584 ****	1.000														
$\boldsymbol{R_{elecutil,t}}$	0.894 ****	0.554 ****	0.856 ****	0.822 ****	0.479 ****	0.827 ****	0.647 ****	1.000													
$\boldsymbol{R_{gasutil,t}}$	0.793 ****	0.417 ****	0.798 ****	0.658 ****	0.455 ****	0.759 ****	0.523 ****	0.634 ****	1.000												
$\boldsymbol{R_{multi,t}}$	0.899 ****	0.515 ****	0.873 ****	0.811 ****	0.482 ****	0.830 ****	0.662 ****	0.729 ****	0.601 ****	1.000											
$\boldsymbol{R_{small,t}}$	0.631 ****	0.572 ****	0.587 ****	0.564 ****	0.390 ****	0.590 ****	0.435 ****	0.605 ****	0.457 ****	0.556 ****	1.000										
$\boldsymbol{R_{big,t}}$	0.999 ****	0.596 ****	0.969 ****	0.883 ****	0.540 ****	0.926 ****	0.718 ****	0.892 ****	0.794 ****	0.899 ****	0.601 ****	1.000									
$\boldsymbol{R_{m,t}}$	0.818 ****	0.517 ****	0.800 ****	0.718 ****	0.450 ****	0.749 ****	0.603 ****	0.739 ****	0.691 ****	0.717 ****	0.547 ****	0.816 ****	1.000								
$LSMB_t$	-0.507 ****	-0.422 ****	-0.485 ****	-0.457 ****	-0.237 ****	-0.476 ****	-0.385 ****	-0.412 ****	-0.410 ****	-0.460 ****	0.123 ****	-0.528 ****	-0.384 ****	1.000							
$LHML_t$	-0.102 ****	0.531 ****	-0.079 ****	-0.285 ****	-0.021 ****	-0.091 ****	-0.080 ****	-0.107 ****	-0.104 ****	-0.130 ****	0.075 ****	-0.110 ****	-0.027 *	-0.060 ****	1.000						
$LUMD_t$	-0.281 ****	-0.151 ****	-0.266 ****	-0.277 ****	0.481 ****	-0.218 ****	-0.757 ****	-0.260 ****	-0.165 ****	-0.272 ****	-0.130 ****	-0.282 ****	-0.240 ****	0.187 ****	0.058 ****	1.000					
$\boldsymbol{R_{tp,t}}$	-0.007	-0.016	-0.013	0.004	-0.018	-0.006	0.009	-0.011	0.003	-0.009	-0.016	-0.007	-0.009	-0.008	-0.022	-0.021	1.000				
$R_{o,t}$	0.020	0.031 **	0.006	0.034 **	0.018	0.008	0.050 ****	0.026 *	0.039 **	-0.003	0.029 *	0.018	0.004	0.002	0.002	-0.033 **	0.025 *	1.000			
$R_{c,t}$	-0.023	-0.011	-0.027 *	-0.007	0.004	-0.033 **	0.002	-0.010	0.001	-0.033 **	-0.027 *	-0.023	0.027 *	-0.017	0.012	0.000	0.007	0.012	1.000		
$R_{g,t}$	0.024	0.029 *	0.023	0.023	0.002	0.032 **	0.044 ***	0.044 ***	0.028 *	0.011	0.031 **	0.023	0.021	0.008	0.010	-0.039 **	0.004	0.005	-0.007	1.000	
$R_{co2,t}$	0.078 ***	0.043 **	0.074 ***	0.085 ***	0.035	0.062 ***	0.058 ***	0.085 ***	0.071 ***	0.065 ***	0.077 ***	0.077 ***	0.082 ***	-0.012	-0.027	-0.031	0.010	-0.029	-0.052 **	0.061 ***	1.000

Note: Correlations between carbon and other variables are estimated over 2,135 observations to reflect the shorter time series.

Regarding the risk factors in Table 5.4, the market beta suggests that the sector is relatively defensive, with a market beta less than unity. The market beta varies across the 12 portfolios, indicating heterogeneous systematic risk exposure. As stated in Sections 3.2.2.3 and 4.3.1, the stock market factors are designed to be modelled in conjunction with the market factor to draw out characteristics buried within the market factor (Fama and French, 1993). Therefore, a detailed interpretation of the pairwise correlations is not presented, as this may result in misleading inferences. Term premium is insignificant across all variables tested. Based on the previous literature, the oil price sensitivity is expected. However, there is unusual significance for some portfolios, such as electricity utilities which rarely use oil in electricity generation. Coal return is expected to have a negative impact as expensive fuel decreases energy utilities' profits. The significance of the natural gas returns has similarities with the oil returns. Oberndorfer (2009a) suggests that stock market participants may be using commodity prices as a main indicator of energy price developments. Carbon risk has a positive correlation with most portfolios tested, the market factor and natural gas, but a negative correlation with coal. Overall, the results are reasonably similar to the variety of coefficients presented Table 3.1.

The magnitude and significance of the pairwise correlations with the risk factors suggest that the majority of portfolios have a differential impact to the risk premia, motivating analytical focus 2. Noticeably, the $LSMB_t$, $LHML_t$ and $LUMD_t$ factors have significant correlations across all energy portfolios, while the commodity risk factors have impacts on each energy portfolio. To address the assumptions of Fama and French (1993), the $LSMB_t$ and $LHML_t$ factors have low pairwise correlations (-0.060). The $LHML_t$ and $LUMD_t$ factors also have low correlation (0.058). The analysis continues with the main results of this chapter.

5.4.2 Econometric Results

This section presents the results of Chapter 5, used to explore the four analytical foci in Section 5.1, including 1) refining the AFFM to produce the local AFFM, 2) examining within-sector heterogeneity across sub-groups of European energy utilities, 3) applying inductive structural break point tests and 4) better isolating the firm-specific component of returns.

5.4.2.1 The local AFFM

Refining the AFFM

The first two analytical foci concern refining the AFFM for explaining returns at the sector level and identifying within-sector heterogeneity. As argued in Section 5.2, the use of local stock market risk factors is expected to have greater explanatory power as regression fits are tight, resulting in higher R^2 values (Fama and French, 2012). The results of the local AFFM are presented in Table 5.5. As highlighted in Section 5.3.1, Table 5.5 also presents the results of the CAPM, augmented-CAPM and (local) four-factor model for completeness and comparability with Chapter 4. Coefficients are estimated between 01 July 1996 and 28 June 2013 (4,435 daily observations). Similar to Chapter 4, carbon price risk will be examined in the inter-temporal analysis (see Section 5.4.2.2). To address assumptions of the linear regression, regression diagnostic tests identified heteroskedasticity and autocorrelation of residuals, which are reported in Table 5.5 and corrected for. All coefficients are estimated using the Newey-West (1987) HAC covariance matrices. The VIFs found no evidence of multicollinearity among variables.

Addressing the first analytical focus, the use of local stock market risk factors captures a greater proportion of returns, further improving the AFFM's goodness of fit. The adjusted R^2 for the energy sector as a whole is 72.77% using the local AFFM (Table 5.5), compared with 68.79% using the global AFFM in Chapter 4 (Table 4.5). These results are congruent with Moskowitz and Grinblatt (1999) and Fama and French (2012). Further, the local AFFM continues to produce the highest adjusted R^2 in comparison with existing asset pricing models: the CAPM (66.96%), the augmented-CAPM (67.17%) and the (local) four-factor model (72.56%). Congruent with the results of Chapter 4, the inclusion of commodities continues to explain only a small proportion of returns, while stock market risk factors have a greater impact on returns.

The following two paragraphs expand on the local AFFM results as the estimated coefficient show some differences relative to the global AFFM results in Table 4.5. For the energy sector as a whole, the local AFFM of Table 5.5 shows that the sector is relatively defensive over the whole time period, with a market beta of 0.6306 ($p \leq 0.001$). Further, the energy sector's returns covary with the returns on big energy utilities (they have a large negative slope on the $LSMB_t$ factor), are marginally tilted towards behaving like low-BE/ME (growth) stocks (they have a small negative slope on the $LHML_t$ factor) and are tilted towards behaving like down momentum utilities (they have a marginally negative slope on the $LUMD_t$ factor). Similar to the results in Table 4.5, coal is the only statistically significant commodity which affects returns at the sector level, with a marginally negative slope.

TABLE 5.5: CAPM, FOUR-FACTOR AND LOCAL AUGMENTED ASSET PRICING MODELS

This table presents the Newey-West regression output for the 12 energy portfolios against eight risk factors, using four model specifications. The 12 value-weighted portfolios include: the energy seetor ($\boldsymbol{R_{util,t}}$), high-BE/ME utilities ($\boldsymbol{R_{high,t}}$), mid-BE/ME utilities ($\boldsymbol{R_{mid,t}}$), low-BE/ME utilities ($\boldsymbol{R_{low,t}}$), upper momentum utilities ($\boldsymbol{R_{upper,t}}$), medium momentum utilities ($\boldsymbol{R_{medium,t}}$), down momentum utilities ($\boldsymbol{R_{down,t}}$), electricity utilities ($\boldsymbol{R_{elecutil,t}}$), natural gas utilities ($\boldsymbol{R_{gasutil,t}}$), multi-utilities ($\boldsymbol{R_{multi,t}}$), small utilities ($\boldsymbol{R_{small,t}}$) and big utilities ($\boldsymbol{R_{big,t}}$). The eight risk factors include: market premium ($\boldsymbol{R_{m,t}}$), local size premium ($LSMB_t$), local value premium ($LHML_t$), local momentum premium ($LUMD_t$), term premium ($\boldsymbol{R_{tp,t}}$), oil risk ($R_{o,t}$), coal risk ($R_{c,t}$) and gas risk ($R_{g,t}$). A ****, ***, ** or * denotes significance at 0.1%, 1%, 5% or 10%, respectively. Specifications are:

Model 1, CAPM: $\boldsymbol{R}_{i,t} = \alpha_i + b_i\boldsymbol{R}_{m,t} + e_{i,t}$,

Model 2, augmented-CAPM: $\boldsymbol{R}_{i,t} = \alpha_i + b_i\boldsymbol{R}_{m,t} + tp_i\boldsymbol{R}_{tp,t} + o_iR_{o,t} + c_iR_{co,t} + g_iR_{g,t} + e_{i,t}$,

Model 3, local four-factor model: $\boldsymbol{R}_{i,t} = \alpha_i + b_i\boldsymbol{R}_{m,t} + s_iLSMB_t + h_iLHML_t + m_iLUMD_t + e_{i,t}$

Model 4, local AFFM: $\boldsymbol{R}_{i,t} = \alpha_i + b_i\boldsymbol{R}_{m,t} + s_iLSMB_t + h_iLHML_t + m_iLUMD_t + tp_i\boldsymbol{R}_{tp,t} + o_iR_{o,t} + c_iR_{co,t} + g_iR_{g,t} + e_{i,t}$,

Where $\boldsymbol{R}_{i,t}$ denotes one of the 12 portfolios as the dependent variable.

For comparison, the global AFFM (Chapter 4, Table 4.5) is included for the energy sector as a whole.

Model (4.4), the global AFFM of Chapter 4: $\boldsymbol{R}_{i,t} = \alpha_i + b_i\boldsymbol{R}_{m,t} + s_iSMB_t + h_iHML_t + m_iUMD_t + tp_i\boldsymbol{R}_{tp,t} + o_iR_{o,t} + c_iR_{c,t} + g_iR_{g,t} + e_{i,t}$,

Portfolio	Model	α_i	b_i	s_i	h_i	m_i	tp_i	o_i	c_i	g_i	$Adj.R^2$	$F =$	Sig.	Mean VIF	Heterosked.	Autocorr.
Energy Sector	1	-0.0001	0.7218 ****								0.6696	1852.86	****	1.00	84.95 ****	33.98 ****
	2	-0.0001	0.7227 ****				-0.0017	0.0109	-0.0371 ****	0.0020	0.6717	486.99	****	1.00	73.23 ****	31.46 ****
	3	0.0001	0.6298 ****	-0.2964 ****	-0.0975 ****	-0.0673 ***					0.7256	1105.38	****	1.12	88.34 ****	34.17 ****
	4	0.0001	0.6306 ****	-0.2975 ****	-0.0973 ****	-0.0661 ****	-0.0430	0.0103	-0.0370 ****	0.0028	0.7277	579.51	****	1.06	79.29 ****	30.14 ****
Energy Sector	(4.4)	-0.0001	0.6896 ****	-0.1369 ****	0.2368 ****	0.0512 ****	-0.0117	0.0113	-0.0323 ***	0.0019	0.6879	347.80	****	1.14	70.28 ****	23.268 ****
High-BE/ME (value)	1	0.0001	0.5320 ****								0.2675	712.75	****	1.00	12.92 ****	5.72 **
	2	0.0001	0.5320 ****				-0.0963	0.0215 **	-0.0235 *	0.0064 *	0.2688	145.24	****	1.00	14.97 ****	6.22 **
	3	0.0001	0.4530 ****	-0.3274 ****	0.6504 ****	-0.0465 **					0.6063	531.82	****	1.12	114.41 ****	10.17 ***
	4	0.0001	0.4535 ****	-0.3287 ****	0.6503 ****	-0.0442 *	-0.0256	0.0203 **	-0.0311 **	0.0053 *	0.6081	269.88	****	1.06	113.44 ****	8.56 ***
Mid-BE/ME (neutral)	1	-0.0001	0.7802 ****								0.6390	1917.89	****	1.00	85.58 ****	13.47 ****
	2	0.0000	0.7813 ****				-0.0436	0.0027	-0.0436 ****	0.0019	0.6411	482.67	****	1.00	74.66 ****	12.37 ****
	3	0.0001	0.6878 ****	-0.3010 ****	-0.0806 ****	-0.0655 ***					0.6837	981.78	****	1.12	88.56 ****	10.88 ****
	4	0.0001	0.6887 ****	-0.3020 ****	-0.0804 ****	-0.0648 ***	-0.0825	0.0021	-0.0437 ****	0.0026	0.6859	514.33	****	1.06	79.78 ****	9.40 ***
Low-BE/ME (growth)	1	-0.0002	0.6225 ****								0.5159	971.76	****	1.00	43.44 ****	9.54 ***
	2	-0.0002	0.6229 ****				0.0693	0.0193 **	-0.0217	0.0022	0.5173	251.26	****	1.00	37.10 ****	8.38 ***
	3	0.0000	0.5252 ****	-0.2925 ****	-0.2866 ****	-0.0783 ****					0.6384	581.12	****	1.12	49.46 ****	13.63 ****
	4	0.0000	0.5255 ****	-0.2934 ****	-0.2866 ****	-0.0765 ****	-0.0012	0.0188 ***	-0.0197 *	0.0034	0.6398	308.26	****	1.06	46.43 ****	11.35 ****
Upper momentum	1	0.0003 ***	0.2409 ****								0.2020	268.08	****	1.00	74.67 ****	2.84 *
	2	0.0003 ****	0.2410 ****				-0.0628	0.0063	-0.0043	-0.0014	0.2019	59.94	****	1.00	75.08 ****	2.62
	3	0.0002 ***	0.2919 ****	-0.1197 ****	-0.0336 ****	0.4294 ****					0.5905	451.10	****	1.12	81.60 ****	15.54 ****
	4	0.0002 ***	0.2919 ****	-0.1204 ****	-0.0338 ****	0.4308 ****	-0.0144	0.0142 ****	-0.0068	0.0030 *	0.5920	233.31	****	1.06	78.27 ****	14.02 ****
Medium momentum	1	0.0001	0.6806 ****								0.5610	1113.38	****	1.00	98.61 ****	11.87 ****
	2	0.0001	0.6816 ****				0.0065	0.0040	-0.0445 ****	0.0048	0.5636	290.75	****	1.00	90.27 ****	11.28 ****
	3	0.0002 *	0.5965 ****	-0.3055 ****	-0.0929 ****	-0.0152					0.6100	573.05	****	1.12	84.18 ****	18.86 ****
	4	0.0002 *	0.5973 ****	-0.3069 ****	-0.0927 ****	-0.0137	-0.0273	0.0043	-0.0448 ****	0.0061 **	0.6129	301.30	****	1.06	77.32 ****	17.75 ****

Table 5.5 (continued)

Portfolio	Model	α_i	b_i	s_i	h_i	m_i	tp_i	o_i	c_i	g_i	$Adj.R^2$	$F =$	Sig.	Mean VIF	Heterosked.	Autocorr.
Down momentum	1	0.0000	0.4336 ****								0.3635	618.59	****	1.00	32.29 ****	12.04 ****
	2	-0.0001	0.4333 ****				0.0778	0.0242 ***	-0.0096	0.0076 ***	0.3666	130.77	****	1.00	43.90 ****	11.59 ****
	3	0.0002 ***	0.2919 ****	-0.1197 ****	-0.0336 ****	-0.5706 ****					0.7727	1213.72	****	1.12	37.91 ****	15.54 ****
	4	0.0002 ***	0.2919 ****	-0.1204 ****	-0.0338 ****	-0.5692 ****	-0.0144	0.0142 ****	-0.0068	0.0030 *	0.7736	615.33	****	1.06	38.89 ****	14.02 ****
Electricity	1	0.0001	0.6466 ****								0.5459	993.46	****	1.00	54.79 ****	19.52 ****
	2	0.0001	0.6467 ****				-0.0352	0.0149 *	-0.0244 *	0.0083 ***	0.5478	261.29	****	1.00	54.45 ****	17.55 ****
	3	0.0002 *	0.5798 ****	-0.1946 ****	-0.0978 ****	-0.0737 ***					0.5785	509.46	****	1.12	61.26 ****	17.70 ****
	4	0.0002 **	0.5798 ****	-0.1963 ****	-0.0982 ****	-0.0715 ***	-0.0714	0.0140 *	-0.0239 *	0.0087 ***	0.5805	268.04	****	1.06	63.61 ****	15.36 ****
Natural gas	1	0.0001	0.8210 ****								0.4776	1617.64	****	1.00	78.95 ****	3.23 *
	2	0.0001	0.8212 ****				0.0755	0.0304 ***	-0.0201	0.0055	0.4790	353.59	****	1.00	73.78 ****	5.44 **
	3	0.0002	0.7428 ****	-0.3171 ****	-0.1404 ****	0.0364					0.5117	533.94	****	1.12	71.41 ****	1.25
	4	0.0002	0.7431 ****	-0.3186 ****	-0.1406 ****	0.0398 *	0.0415	0.0318 ***	-0.0203	0.0074 *	0.5134	281.39	****	1.06	69.10 ****	3.13 *
Multi-utilities	1	0.0000	0.6855 ****								0.5141	1025.87	****	1.00	57.21 ****	35.51 ****
	2	0.0000	0.6869 ****				-0.0161	-0.0035	-0.0459 ***	-0.0012	0.5163	269.74	****	1.00	52.61 ****	34.23 ****
	3	0.0001	0.5846 ****	-0.3096 ****	-0.1386 ****	-0.0915 ***					0.5752	563.13	****	1.12	57.84 ****	21.51 ****
	4	0.0002	0.5857 ****	-0.3102 ****	-0.1381 ****	-0.0917 ****	-0.0678	-0.0044	-0.0453 ***	-0.0005	0.5775	291.09	****	1.06	57.67 ****	20.04 ****
Small utilities	1	0.0001	0.3880 ****								0.2990	706.55	****	1.00	10.43 ***	19.70 ****
	2	0.0002	0.3884 ****				-0.0677	0.0137 *	-0.0276 ***	0.0045 *	0.3014	147.27	****	1.00	10.17 ***	17.31 ****
	3	0.0000	0.4934 ****	0.4280 ****	0.1014 ****	-0.0400 **					0.4449	367.18	****	1.12	31.76 ****	30.17 ****
	4	0.0000	0.4940 ****	0.4271 ****	0.1015 ****	-0.0388 **	-0.0329	0.0122 *	-0.0266 ***	0.0023	0.4468	194.94	****	1.06	32.18 ****	28.15 ****
Big utilities	1	-0.0001	0.7439 ****								0.6652	1778.54	****	1.00	88.83 ****	31.39 ****
	2	-0.0001	0.7448 ****				0.0033	0.0103	-0.0383 ***	0.0018	0.6672	469.94	****	1.00	76.24 ****	29.17 ****
	3	0.0001	0.6392 ****	-0.3432 ****	-0.1109 ****	-0.0691 ***					0.7336	1133.70	****	1.12	95.00 ****	32.77 ****
	4	0.0001	0.6400 ****	-0.3442 ****	-0.1107 ****	-0.0679 ***	-0.0430	0.0098	-0.0383 ****	0.0028	0.7357	594.18	****	1.06	84.80 ****	28.86 ****

Before continuing with the second analytical focus of the chapter, the differences between the estimated coefficients of Chapters 4 and 5 are addressed. As stated in Section 5.1 and shown in Figure 5.1, the global approach of Chapter 4 asks how the energy sector behaves *relative to other European stocks and sectors* (levels A and B), while the local approach of Chapter 5 explores how the energy portfolio behaves *relative to other European energy utilities* (level B and C).

The largest difference between Tables 5.5 and 4.5 occur in the HML slopes; thus, this paragraph concentrates on explaining this difference. Chapter 4 (Table 4.5) showed that the energy utility sector behaved like high-BE/ME European stocks based on the global risk factors, typically associated with distressed firms. In contrast, Chapter 5 (Table 5.5) shows that there is a slightly negative coefficient with the $LHML_t$ factor, suggesting a marginal tilt towards the low-BE/ME (growth) utilities. To address the former result for Chapter 4, the discussion of firm characteristics in Appendix B shows that the BE/ME ratios of most energy utility portfolios (Table B.2) are higher than those observed for European stocks (Table B.1). The implication is that the market perceives utilities to be a riskier investment compared with the average European stock. Therefore, the energy sector should be tilted towards high-BE/ME coefficients when measured against global stock market risk factors, explaining the positive HML_t slope in Table 4.5. When exploring within sector returns, and to address the results of Chapter 5, the pairwise correlations in Table 5.4 show that the energy sector as a whole has a correlation of 0.968 with the mid-BE/ME (neutral) energy portfolio, and a higher correlation with the low-BE/ME (growth) portfolio (0.884) compared with the high-BE/ME (value) portfolio (0.605). The interpretation of this data is that the sector as a whole behave like mid-BE/ME utilities, but is marginally tilted towards behaving like low-BE/ME utilities in comparison with high-BE/ME utilities.

Concluding the implications for the first analytical focus, the AFFM can be refined in two ways. First, the use of local stock market risk factors explains a greater proportion of returns at the sector level, a distinct improvement over the global stock market risk factors of Chapter 4. Second, by using various portfolios of energy utilities, a greater understanding of the impact of risk factors on sector returns can be achieved. In particular, the paragraph above showed sector level peculiarities which would otherwise have been obscured if relying on the local risk factor in isolation. Relevant to the latter point, the following paragraphs outline within-sector heterogeneity of various portfolios of energy utilities grouped on similarity of characteristics.

Within-Sector Heterogeneity

The second analytical foci of this chapter is concerned with identifying within-sector heterogeneity. Accordingly, this section first examines the spread in returns across various energy portfolios grouped on characteristics to investigate whether the return profiles of mutually exclusive portfolios are indeed different. Following this, the second analytical foci is addressed directly by implementing the local AFFM (Equation 5.1) to examine the risk exposure at the portfolio-level. Across the 12 portfolios tested, the local AFFM produces a variety of coefficient magnitudes and significance tests. The policy implication of the varying coefficients suggests that the risk exposure of energy utilities depends on firm characteristics. Table 5.6 presents the spread in expected returns as a result of the estimated coefficient spread using the method of Fama and French (1993) outlined in Chapter 4, Section 4.3.2.1. The following paragraph addresses each coefficient.

TABLE 5.6: EXPECTED SPREAD IN RETURNS

This table presents the estimated spread in returns as a result of the spread in estimated coefficients (from Table 5.5). In line with Fama and French (1993), the expected spread in return is the difference between the greatest- and smallest-estimated coefficients for each risk factor. The annualised risk factors are extracted from Table 5.2 and include: the market factor ($\boldsymbol{R_{m,t}}$), local size premium ($LSMB_t$), local value premium ($LHML_t$), local momentum premium ($LUMD_t$) term premium ($\boldsymbol{R_{tp,t}}$), oil risk ($R_{o,t}$), coal risk ($R_{c,t}$) and gas risk ($R_{g,t}$). The coefficient spread, multiplied by the risk factor's annualised return can predict the spread in average returns between the two portfolios with the greatest and least sensitivity to the risk factor.

		Estimated Coefficient						
Row	**Coefficient**	**Min Coef. (a)**	**Portfolio**	**Max Coef. (b)**	**Portfolio**	**Spread in Coefficients (a)-(b)**	**Risk Factor (Annual Return) (d)**	**Spread in Expected Return [(a)-(b)] × (d)**
(A)	b_i	0.292	Upper and Down momentum	0.743	Natural Gas utilities	0.451	0.95%	0.43%
(B)	s_i	-0.344	Big utilities	0.427	Small utilities	0.771	8.35%	6.44%
(C)	h_i	-0.287	Low-BE/ME	0.650	High-BE/ME utilities	0.937	4.91%	4.60%
(D)	m_i	-0.569	Down momentum	0.431	Upper momentum	1.000	8.48%	8.48%
(E)	tp_i	-0.082	Mid-BE/ME utilities	0.041	Natural Gas utilities	0.124	7.04%	0.87%
(F)	o_i	-0.004	Multi-utilities	0.032	Natural Gas utilities	0.036	10.46%	0.38%
(G)	c_i	-0.045	Multi-utilities	-0.007	Upper and Down momentum	0.039	4.20%	0.16%
(H)	g_i	-0.001	Multi-utilities	0.009	Electric utilities	0.009	11.66%	0.11%

First, row (A) of Table 5.6 shows a spread in market beta (b_i) of 0.451, however, the overall spread in expected return of 0.43% is small due to the market factor having an annualised return close to zero (0.95%). This is congruent with the results in Section 4.3.2.1. Rows (B) to (D) show that there are large spreads in expected returns between portfolios as a result of the stock market risk factors. The spread in returns vary from 4.60-8.48%. Naturally, the mutually exclusive size, value and momentum portfolios show the greatest sensitivity with the stock market risk factors. Chapter 4 found that the HML factor was also not significantly different from zero, resulting in an expected spread in returns of only 0.64% per annum. In contrast, Chapter 5 (Table 5.2) showed a significant local HML factor for energy utilities of

4.60% per annum suggesting much greater value premium in the energy utility sector in comparison with other European stocks. The policy implication of this result is that the energy sector is distressed relative to other European stocks. The following paragraph addresses the term premium and commodity risk factors.

Chapter 4 showed that the expected spread in returns as a result of term premium and commodities was small in comparison with the global stock market risk factors. Despite refining the AFFM to improve the accuracy of estimated coefficients, the overall result of this chapter are qualitatively the same as Chapter 4: commodity risk factors contribute little to explaining returns in the energy sector. Rows (E) to (H) of Table 5.6 show that term premium and commodities explain less than 0.87% spread in expected returns. The additional contribution of this chapter is showing that, for the most part, the industry portfolios have the greatest sensitivities to the commodity risk factors, but the commodities themselves still play a minor role in asset pricing.

As argued in Section 3.3.5.2, the small impact of commodities may be the result of hedging behaviour but still warrants discussion. The detection of oil price risk may indicate that various utilities are either using oil in production, are holding quantities of (or have investments in) oil that have changed in value and therefore affected firm value (Söderholm, 2001); or that market participants must be benchmarking sector performance against oil price changes (Oberndorfer, 2009a). The results for coal are relatively consistent with Oberndorfer (2009a); there’s a negative relationship with coal prices and coal risk has a smaller impact than oil risk. The surprising finding is the small impact for natural gas. Two possible explanations for this small impact for natural gas exist: 1) energy firms are expected to hedge against natural gas price risk (Haushalter, 2000) or 2) it is possible that the oil returns are capturing some of the gas impact. Such an interpretation would be consistent with the indexing of natural gas prices to oil prices (Siliverstovs et al., 2005)

The following paragraphs address the second analytical foci directly by examining the results of the 12 energy portfolios in their mutually exclusive groupings: the two size portfolios, the three book-to-market portfolios, the three momentum portfolios, and the three industry portfolios. As the regulatory changes in Section 2.2 are expected to predominantly affect firms based on size and industry, the results section primarily focuses on these two groupings. The first observation regarding the energy portfolios is that it is rare for portfolios to experience extreme size, value or momentum tilt. That is to say, using momentum as an example, no portfolio’s returns are solely explained by upper or down momentum. In reality, Table 4.4 shows that all portfolios have the greatest covariance with medium momentum, but are only slightly tilted towards upper or down momentum, which can be determined by the size of the upper and down momentum’s coefficients.[58] The previous interpretation will be useful for within-sector heterogeneity. A summary of the heterogeneous impact of risk factors from Table 5.5, delineated by portfolios, is provided in Table 5.7 and discussed in the following paragraphs.

TABLE 5.7: SUMMARY OF HETEROGENEOUS IMPACT OF RISK FACTORS

This table summarizes the impact of significant risk factors from the local AFFM in Table 5.5, where a “$+$” indicates a significant positive coefficient was observed and “$-$” indicates a significant negative coefficient was observed.

Portfolio	α_i	b_i	s_i	h_i	m_i	tp_i	o_i	c_i	g_i
Energy Sector		+	-	-	-			-	
High-BE/ME		+	-	+	-		+	-	+
Mid-BE/ME		+	-	-	-			-	
Low-BE/ME		+	-	-	-		+	-	
Upper momentum	+	+	-	-	+		+		
Medium momentum		+	-	-				-	+
Down momentum	+	+	-	-	-		-		
Electricity utilities	+	+	-	-	-		+	-	+
Natural gas utilities		+	-	-			+	-	+
Multi-utilities		+	-	-	-			-	
Small utilities		+	+	+	-		+	-	
Big utilities		+	-	-	-			-	

Addressing the two size portfolios in Table 5.7, the interpretation for big utilities is similar to the sector as a whole. Big utilities have a market beta of 0.640 and have a negative SMB slope, which is expected. Big utilities are tilted towards behaving like low-BE/ME utilities (a negative h_i coefficient) and tilted towards down momentum (negative m_i coefficient). Coal is the only significant commodity risk factor for big utilities, with a negative impact. The local AFFM typically performs poorly at explaining the returns on small energy utilities, with an adjusted R^2 of 44.68%, consistent with the argument that smaller firms are typically harder to value and often informationally sparse (Kumar, 2009). Overall, small energy utilities are still defensive investments, with a market beta of 0.494, but are exposed a larger number of stock market and commodity risk factors in comparison with big utilities. Naturally the small utilities are expected to have a positive SMB slope, but they also behave like high-BE/ME (value) utilities (positive h_i coefficient) and are marginally tilted towards down momentum (negative m_i coefficient). The positive size and value premia are

---

[58] To illustrate, consider the big energy utility portfolio. Table 5.4 shows that big utilities have the greatest covariance with the medium momentum portfolio (0.926). Between the extreme momentum portfolios, big utilities have higher covariance with the down momentum portfolio in comparison with the upper momentum, a covariance of 0.718 in comparison with 0.540, respectively. Momentum for big utilities is tilted towards down momentum. This is congruent with the local AFFM results in Table 5.5, where the $LUMD_t$ coefficient of -0.068 shows that big utilities are marginally tilted towards down momentum. The pairwise correlation in Table 5.4 allow greater insight into the results of the local AFFM.

consistent with utilities being distressed and/or marginal firms, requiring greater return on investment. Small utilities have positive oil risk and negative coal risk. The increased commodity risk exposure suggests that small utilities do not effectively hedge against commodity risk.

Regarding the three book-to-market portfolios, the mid-BE/ME (neutral) energy utilities have the greatest systematic risk, in comparison with high-BE/ME (value) and low-BE/ME (growth) utilities. The size premium suggests that the three portfolios behave like big energy utilities, while the momentum premium shows that the portfolios show some tilt towards down momentum. Interestingly, the high-BE/ME utilities, which are typically associated with firm distress and fallen angels, show sensitivities to all commodities: oil, coal and natural gas risk. In contrast, the mid- and low-BE/ME portfolios show less commodity risk exposure. The significant commodity risk of the high-BE/ME and small utilities is consistent with Oberndorfer's (2009a) and Kumar's (2009) propositions: commodities serve as informational signals for price developments in the energy sector when less information is available.

Due to econometric reasons, this chapter chooses to withhold from drawing inferences regarding the three momentum portfolios. The first reason relates to Fama and French (2012), who argue that local models have difficulty when capturing average returns for portfolios with extreme momentum. Extreme momentum tilts are rare in reality, but the upper and down momentum portfolios in Section 5.4.1.1 were purposely designed to capture extreme (30th and 70th percentile) momentums. Second, Sections 4.2.4 and 5.3.3 noted that the UMD risk factors were rebalanced daily; an active portfolio strategy such as momentum requires extremely high turnover (Moskowitz and Grinblatt, 1999). The momentum strategy does not represent a realistically viable investment opportunity, as trading costs would have a negative impact on the strategy's performance (Rosenberg et al., 1985). Moreover, the daily rebalancing suggests that the upper and down momentum portfolios should be mostly explained by the UMD factor. Moskowitz and Grinblatt (1999) find that significance of industry momentum is greater than all other stock market risk factors, including individual firm momentum. Evidence for this is shown in Table 5.5. With the exception of the UMD factor, the estimated coefficients for the upper and down momentum portfolios are all identical to each other. Further, the spread between the UMD coefficients for the upper and down momentum portfolios equals 1; this effect remains throughout the upcoming inter-temporal analysis. Note, none of the criticisms above affect the use of the UMD risk factor when used to explain returns on other energy portfolios. In summary, the UMD risk factor is useful as an independent variable but encounters known econometric issues as a dependent variable.

The following addresses the three industry portfolios in Table 5.7. First, the electricity industry has the lowest market beta, is tilted towards big stock (negative s_i coefficient), is marginally tilted towards low-BE/ME (negative h_i coefficient) and also marginally tilted towards down momentum (negative m_i coefficient). The electricity industry has the greatest commodity risk exposure of all three industries; all commodities are statistically significant. Second, the natural gas industry has the highest market beta of the three industries, showing increased systematic risk. Natural gas utilities behave like big utilities (negative s_i coefficient), are tilted towards low-BE/ME (growth) utilities (negative h_i coefficient) and tilted towards upper momentum (positive m_i coefficient). The natural gas industry is the only industry with positive momentum, possibly indicating excess profiteering (see Section 1.2). Unsurprisingly, the natural gas sector has positive relationships with oil and natural gas prices. The implications for the sector are that they generally perform well relative to other utilities and have a larger market capitalisation. Finally, the multi-utility sector, unsurprisingly, shares risk exposure with both electricity and natural gas utilities. Table 5.5 shows that the multi-utility portfolio shares similar market beta, $LUMD_t$ and coal price coefficients with the electricity industry, and similar $LSMB_t$ and $LHML_t$ coefficients with natural gas industry. This result is expected as the multi-utilities contain a combination of electricity and natural gas operations (see Section 5.3.2.1). Interestingly, the multi-utility industry has little commodity risk exposure, suggesting either effective hedging strategies or economy of scope; diversified operations allows energy utilities to switch operations when faced with regulatory changes or commodity price fluctuations.

Concluding the implications for the second analytical focus, the results of the local AFFM show within-sector heterogeneity with regard to stock market, term premium and commodity risk factors. The majority of previous inferences regarding the energy utility sector, such as those presented by commentators in Section 1.2, has implicitly referred to the impact on big utilities. As shown above, big utilities represent the sector as a whole, while small utilities have a dramatically different return profile and risk exposure. In particular, small utilities are more sensitive to commodity risk. Second, inferences regarding the impact from regulations or renewables on the energy sector are inherently biased and unrepresentative if the energy sample primarily contains the natural gas majors, for example, The Economist (2013a, b, c, 2015) and The BBC (2013). With the exception of value premium, the risk premia for the natural gas utilities are similar to those observed for the oil & gas sector in Chapter 4 (Table 4.5). Section 3.2.3.3 argued that many European energy utilities are integrated and, therefore, no ‘pure’ natural gas producer exists (Oberndorfer, 2009a). Further, Table 5.1 shows that many operations between the two sectors are integrated or overlap. This is a pressing issue as many of the regulatory changes in Section 2.2 were designed to reduce reliance on hydrocarbon fuel sources, which must negatively impact the natural gas industry but provide growth opportunities for the electricity industry. Forthcoming results in Chapter 6 also show that natural gas utilities typically have strong negative reaction to regulatory changes. The impact is mostly independent to those observed for electricity utilities and multi-utilities.

Another observation of the results is the insignificance of term premium across all portfolios tested. The mean coefficient for term premium, t_i, is -0.008, ranging from -0.096 to 0.078; all are insignificant, which suggests that borrowing costs have no impact on all 12 portfolios. This result is consistent with Chapter 4 and Oberndorfer (2009a).

The following two sections outline tests concerning the evolving relationship with risk premia through time. The deductive conditional annual regressions are presented in Section 5.4.2.2, while the inductive structural break point tests are presented in Section 5.4.2.3. Although the conditional regressions do not directly address the analytical foci of this chapter, they are included for various reasons. First, the conditional regressions are comparable with those presented in Chapter 4 (Section 4.3.2.2). Second, the annual regressions allow the inclusion of carbon prices from 2006 onwards. Third, the conditional regressions represent a model utilised in current literature (see El-Sharif et al., 2005). Thus, the conditional annual local AFFM in Section 5.4.2.2 explores the performance of an existing approach to measuring parameter stability. Section 5.4.2.3 addresses the third analytical focus of the chapter: applying inductive rather than deductive structural break point tests, which improves the AFFM's goodness of fit and estimation of break dates.

5.4.2.2 Inter-temporal analysis

As noted previously (see Section 3.3.4 and 4.3.2.2), the established literature has reported substantial inter-temporal and inter-sectoral variability in the relationships between average returns and risk factors (Faff and Brailsford, 1999, Sadorsky, 2001, El-Sharif et al., 2005, Oberndorfer, 2009a, Fama and French, 1997, 1998, 2012). To address time-varying risk loadings, the time series is separated into annual periods and the local AFFM, Equation (5.2), is implemented annually. This provides results comparable with Chapter 4 and El-Sharif et al. (2005). Following this, we improve the estimates of time-varying risk loading using the Bai and Perron (1998; 2003) inductive structural breakpoint tests. Table 5.8 reports the annual regression results for the energy sector portfolio, estimated using Newey-West HAC standard errors. Regression coefficients through time and 95% confidence intervals are shown in

Figure 5.6. For comparison, regression output for the remaining 11 portfolios and plots of evolving coefficients, including confidence intervals, are reported in Appendix D.

Overall, the results indicate evolving risk premia over the entire time series. Further, the inter-temporal AFFM improves the goodness of fit, from an adjusted R^2 of 72.77% in the unconditional regression of Table 5.5 to a mean adjusted R^2 of 74.52% in Table 5.8. The use of local risk factors also improves the goodness of fit compared with global risk factors, producing a mean adjusted R^2 of 74.52% (Table 5.8) compared with 69.64% (Table 4.7).

The conditional regressions show a significant intercept between 2003 and 2007, suggesting the sector generated abnormal return pre-GFC, but is also consistent with the interim period between the second and third liberalisation packages. Further, the market betas are consistently positive and significant through time, but marginally lower than the market betas observed in Table 4.7. This is due to the poor performance of the global stock market risk factors in Chapter 4, failing to accurately capture local size, value and momentum-premia at the sector level. Further, the estimated coefficients in Chapter 4 are relative to all *European stocks*; the risk factors continue to be absorbed by the market factor, making the sector appear to have greater systematic risk than the true underlying market beta. The results in Table 5.8 show the energy sector’s beta is defensive and relatively volatile until 2004, fluctuating around 0.45. There is an upward shift in market beta occurring in 2005, congruent with results in Section 4.3.2.2. Post-2005, the beta is relatively stable, fluctuating round 0.72.

The local SMB coefficients are negative and significant for all 18 years tested. The results show that the average returns in the energy sector behave like big energy utilities through time. The relationship is not stable through time; there are years where the SMB coefficient becomes more negative, suggesting that the returns of big utilities have greater influence on overall sector returns. The size results are consistent with those observed in Table 4.7, but with greater significance. For Table 4.7, the global SMB coefficients become more negative from 2008 onwards, indicating that energy sector returns behave like the biggest European stocks. In Table 5.8, the magnitude of negative coefficients is large around 1999 and 2008; the biggest utilities have a large influence on energy sector returns in these years. The spread between big utilities and small utilities is increasing, which suggests that liberalisation policy, which was supposed to benefit small and new-entrant companies (see Section 2.2), has been ineffective and large utilities continue to dominate sector returns.

TABLE 5.8: INTER-TEMPORAL ANALYSIS OF SECTOR PORTFOLIO USING THE LOCAL AFFM

This table presents conditional annual local AFFM, estimated on a year-by-year basis using Newey-West HAC standard errors between 1996 and 2013. The value-weighted returns of the energy sector ($\boldsymbol{R_{util}}$) is used as the dependent variable. The nine risk factors include: market premium ($\boldsymbol{R_m}$), local size premium ($LSMB$), local value premium ($LHML$), local momentum premium ($LUMD$), term premium ($\boldsymbol{R_{tp}}$), oil risk (R_o), coal risk (R_c), natural gas risk (R_g) and carbon risk (R_{co2}). The intercept and error term is denoted α_i and e, respectively. A ****, ***, ** or * denotes significance at 0.1%, 1%, 5% or 10%, respectively. The specification used is:

$$\boldsymbol{R_{util}} = \alpha_i + b_i\boldsymbol{R}_m + s_i LSMB + h_i LHML + m_i LUMD + tp_i\boldsymbol{R}_{tp} + o_i R_o + c_i R_{co} + g_i R_g + co2_i R_{co2} + e.$$

Year	α_i	b_i	s_i	h_i	m_i	tp_i	o_i	c_i	g_i	$co2_i$	$\boldsymbol{adj.R^2}$	$\boldsymbol{F =}$	***Sig.***
1996[A]	0.0000	0.5148 ****	-0.4256 ****	0.0776 *	0.0748	0.5126 **	-0.0175	-0.0392	-0.0081		73.58%	46.60	****
1997	0.0001	0.5709 ****	-0.3323 ****	0.0470	0.1591 ****	-0.0679	0.0119	-0.0179	0.0076		80.27%	133.24	****
1998	0.0003	0.4935 ****	-0.3486 ****	0.0035	-0.0399	0.0576	0.0117	-0.0803 ****	0.0003		77.83%	115.07	****
1999	-0.0003	0.3297 ****	-0.6388 ****	0.0335	-0.0129	0.0299	-0.0073	0.0314 ***	-0.0015		80.79%	137.68	****
2000	0.0006	0.2291 ****	-0.4463 ****	-0.0072	-0.0070	-0.4484	0.0018	0.0262	-0.0015		45.83%	28.39	****
2001	0.0003	0.3927 ****	-0.3747 ****	-0.0758	-0.0280	0.1708	0.0238	-0.0193	0.0055		67.36%	68.08	****
2002	0.0000	0.5029 ****	-0.3191 ****	0.0404	-0.0556 *	-0.0981	-0.0297	0.0065	0.0030		84.76%	181.73	****
2003	0.0004 *	0.4696 ****	-0.3819 ****	-0.1531 ****	-0.0923 **	0.2921	-0.0055	-0.0718 **	-0.0022		85.15%	187.37	****
2004	0.0008 ****	0.5517 ****	-0.2240 ****	-0.0610 *	0.0703	0.0355	0.0046	-0.0245	0.0038		66.06%	64.51	****
2005	0.0004	0.8385 ****	-0.1151 ***	-0.0993 ***	0.0785	0.1272	-0.0097	-0.0186	-0.0005		61.90%	53.59	****
2006	0.0005 **	0.7548 ****	-0.1295 ****	-0.0902 **	0.0559	0.0948	0.0551 ****	-0.0046	0.0021	0.0093 **	71.08%	71.72	****
2007	0.0006 *	0.6208 ****	-0.2301 ****	-0.0627 *	0.0646	-0.4056	0.0605 **	-0.0071	-0.0042	0.0006 *	67.23%	60.27	****
2008	0.0001	0.6559 ****	-0.4474 ****	-0.3765 ****	0.0034	0.1124	0.0214	-0.0517 **	0.0238 *	-0.0032	85.03%	165.69	****
2009	0.0002	0.5695 ****	-0.4310 ****	-0.2592 ****	-0.0999 **	-0.3600	0.0186	0.0306 *	-0.0051	0.0011	78.67%	107.53	****
2010	-0.0080	0.7551 ****	-0.2447 ****	-0.1819 ****	-0.1251 ****	4.3887	0.0410 **	-0.0460 **	0.0064	-0.0084	85.34%	169.15	****
2011	0.0000	0.8207 ****	-0.3054 ****	0.0723	-0.0682 *	-0.1636	0.0237	-0.0093	0.0073	0.0064	84.06%	152.74	****
2012	0.0000	0.7282 ****	-0.1719 ****	0.1762 ****	-0.1989 ****	-0.1061	-0.0176	-0.0192	-0.0164	0.0114	74.35%	84.75	****
2013[A]	-0.0020	0.7334 ****	-0.2738 ****	0.1586 ***	-0.1887 ***	1.0720	-0.0368	-0.0055	-0.0285	0.0043	72.04%	37.65	****
Mean:	-0.0003	0.5851	-0.3244	-0.0421	-0.0228	0.2913	0.0083	-0.0178	-0.0005	0.0027	74.52%		

[A] Due to rebalancing in June, data contains six months of observations.

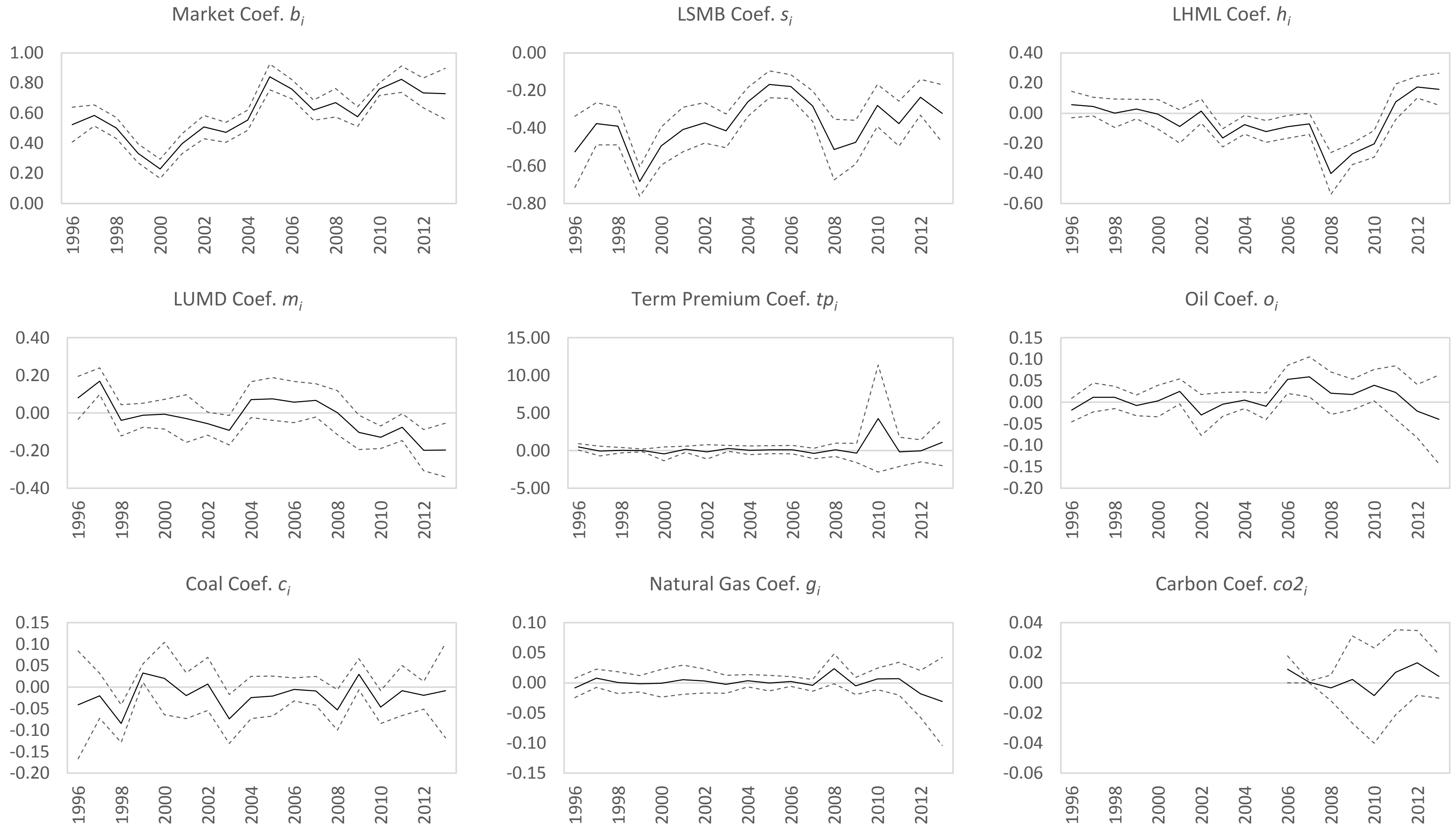


FIGURE 5.6: LOCAL AFFM ESTIMATED COEFFICIENTS AND 95% CONFIDENCE INTERVALS OVER TIME

This figure illustrates the estimated coefficients for the nine risk factors through time, using the annual local AFFM results from Table 5.8. The solid line represents the estimated coefficient, while the dotted line represents the 95% confidence interval. When the 95% confidence interval overlaps zero, the test of significance fails at the 5% level.

The local HML coefficients are nominally negative for 10 of the 18 years tested, eight of which were significant. This indicates that average returns in the energy sector covary with those of the low-BE/ME (growth) utilities through time.[59] However, the years 2011 to 2013 show a shift in the HML coefficient, with 2012 and 2013 being positive and significant. This shows that average returns in the energy utility sector behave like high-BE/ME (value) stocks between 2011 and 2013, typically associated with firm distress. This effect is not isolated, Appendix D and Figure D.3 show that many European portfolios all experience this shift. Further, the inter-temporal analysis in Table 4.7 of Chapter 4 also showed that the energy utility sector showed greater firm distress from 2011 and 2012, relative to other European stocks. This may indicate an exogenous shock that made European energy utilities a relatively riskier investment.

The global UMD coefficient in Table 4.7 showed that the energy utility sector performed well relative to other European stocks until 2009. After 2009, the sector performed poorly in comparison with European stocks. The local UMD coefficients in Table 5.8 show a similar pattern. The average returns of the utility sector are rarely affected by momentum. The energy sector as a whole only behaved like upper momentum utilities in 1997. Of the 18 years tested, only seven years produce results consistent with the energy sector behaving like down momentum utilities. In particular, down momentum utilities explain average sector returns in 2002 and 2003, and from 2009 onwards. Again, this is consistent with an exogenous shock to the energy sector which negatively impacted financial return. The timing of these two shocks coincide with the second and third packages of liberalisation, 2003 and 2009, respectively (see Section 2.2.1).

The results of the stock market risk factors above show a clear trend. Average returns in the energy sector are typically explained by defensive, big, low-BE/ME (growth) and upper momentum energy utilities until 2009/2010. Around this period, the energy sector begins to take on increasing systematic risk and average returns begin to be explained by big, high-BE/ME (value) and down momentum energy utilities. This could be consistent with one of two major events which occur during this time period. First, the results would be consistent with poor performance post-GFC and during the EUC; however, macroeconomic factors are controlled for by including the market factor. Second, the results are consistent with the publication of the third packages of liberalisation, designed to counter market dominance from big energy utilities (see Section 2.2.1). The latter is the most plausible explanation;

---

[59] For clarity, this result does not conflict with those in Chapter 4, Section 4.3.2.2. While growth utilities explain energy sector returns, the energy sector as a whole is relatively more distressed compared with other European stocks.

Chapter 6 will test the impact of regulatory changes on financial return. The following paragraph addresses commodity risk exposure through time.

For the most part, commodities continue to explain very little in energy sector returns. The commodity risk factors presented in Table 5.8 are mostly consistent with those presented in Chapter 4 (Table 4.7), with some minor differences. Natural gas produces one marginally significant coefficient in 2008, remaining insignificant otherwise; indicating effective hedging strategies over time. The carbon becomes significant in 2006 and 2007; insignificant thereafter. Results are consistent with El-Sharif et al. (2005); there is varying commodity risk exposure across time. The number of significant commodity coefficients increases in later years, possibly reflecting the uncertainty of rapidly changing commodity prices observed in Figure 4.3. Appendix D shows that these patterns of significance were not constant across portfolios; each portfolio exhibits its own pattern of evolving risk exposure and significance.

In summary, the comparison of results between Chapter 5 (Table 5.8) and Chapter 4 (Table 4.7) show that the direction, magnitude and significance of stock market, term premium and commodities varies depending on the use of global or local stock market risk factors. Having explored the performance of the local AFFM using a deductive method of examining parameter stability, the following section utilises the inductive Bai and Perron (1998; 2003) structural break point test, addressing analytical focus 3 of the chapter.

5.4.2.3 Structural break point tests

Sections 4.3.2.2 and 5.4.2.2 examine time-varying risk premia using a deductive approach of defining annual break points, which has been implemented in prior literature (see El-Sharif et al., 2005). Section 3.3.3.2 and 5.1 highlighted that this method can bias estimated coefficients by including excess observations. An alternative approach is an inductive approach which detects unknown structural changes in the relationship between sector returns and risk premia. To this end, this section implements the Bai and Perron (1998; 2003) parameter stability diagnostic test and break point regression. The Bai and Perron (1998; 2003) tests are implemented using *EViews* and outlined in detail in Section 5.3.1. Daily returns in the energy sector, between 01 July 1996 and 28 June 2013, are used for all structural break point tests. The break point test is implemented using the local AFFM (Equation 5.1), rather than the global AFFM of Chapter 4, as the local stock market risk factors have tighter regression fits. The results in Table 5.9 present the stability diagnostic tests, while the results in Table 5.10 present the results of the break point regression. The break conditions of the two tests are also outlined in Table 5.9 and Table 5.10. The following paragraph addresses the first stage of analysis: the post-hoc stability diagnostic test.

Parameter stability in the local AFFM (Section 5.4.2.1, Table 5.5) is examined using the Bai and Perron (1998; 2003) parameter stability diagnostic test. The diagnostic test identifies the potential number of structural breaks in all parameters of the local AFFM regression. The sequential procedure tests the hypothesis of ℓ versus $\ell + 1$ breaks. The results are presented in Table 5.9. The results of the F-tests are all significant between one and eight breaks, indicating a minimum of one and a maximum of eight structural breaks in the time series. The F-stat diminishes as the ninth break appears. The repartition dates serve as likely candidates for the eight structural breaks, where one or more of the parameters have shifted. Based on evidence of the existence of structural breaks the local AFFM, the second stage of the Bai and Perron (1998; 2003) test is implemented: the break point regression.

The second stage implements the Bai and Perron (1998; 2003) break point regression, specifying the local AFFM (Equation 5.1) as the mean equation. Using the method outlined in 3.3.4.1, the break point regression minimises the SSR using a dynamic algorithm, subject to break conditions outlined in Table 5.10. The sequential procedure also tests the hypothesis of ℓ versus $\ell + 1$ breaks, the information criterion is set to allow a maximum of 18 structural breaks, employs a trimming percentage of 5% and significance at $p \leq 10\%$. The result of the break point regression is shown in Table 5.10. The result show that the estimated break points are identical to those in Table 5.9, identifying eight structural breaks in the time series.

The Bai and Perron (1998; 2003) break point regression provides marked improvements to regression fits for the energy sector. The initial full-period global AFFM of Chapter 4 produced an adjusted R^2 of 68.79% (Table 4.5). The adjusted R^2 of the inter-temporal global AFFM varied between 28.24% and 85.63%, with a mean of 69.64% (Table 4.7). For Chapter 5, the full-period local AFFM in Table 5.5 produced an adjusted R^2 of 72.77%. The adjusted R^2 values of the annual regressions in Table 5.8 fluctuate between 45.83% and 85.34%, with a mean of 74.52%. When controlling for inductive structural breaks, the Bai and Perron (1998; 2003) break point regression increases the adjusted R^2 of the AFFM to 80.42%. Addressing analytical focus 3, the use of local stock market risk factors and utilising the inductive method of controlling for structural breaks improves the goodness of fit compared with all other specifications tested. The following paragraph continues by interpreting the results.

TABLE 5.9: LOCAL AFFM STABILITY DIAGNOSTIC TESTS

This table presents the stability diagnostic tests for Equation (5.1) and results of Section 5.4.2.1. The results are estimated using sequential evaluation, a maximum of 18 breaks and a trimming percentage of 5%. Repartition are suspected break dates.
* Significance at $p \leq 10\%$
** Critical values from Bai and Perron (2003).

Break Test	**F-statistic**	**Scaled F-statistic**	**Critical Value****	**Sequential**	**Repartition**
0 vs. 1 *	23.49	187.89	22.92	01/11/2004	01/09/1998
1 vs. 2 *	15.22	121.76	25.15	01/09/1998	30/03/2000
2 vs. 3 *	10.73	85.83	26.38	07/07/2010	10/09/2001
3 vs. 4 *	15.72	125.73	27.09	18/06/2008	01/09/2004
4 vs. 5 *	8.44	67.54	27.77	18/05/2001	25/07/2007
5 vs. 6 *	5.03	40.21	28.15	30/03/2000	18/06/2008
6 vs. 7 *	4.97	39.80	28.61	28/04/2009	28/04/2009
7 vs. 8 *	4.34	34.69	28.90	25/07/2007	01/02/2011
8 vs. 9	2.82	22.59	29.19	Nil	Nil

TABLE 5.10: RESULTS OF THE LOCAL AFFM BREAK POINT REGRESSION

This table presents the results of the Bai and Perron (1998; 2003) sequential multiple partial break point tests. The HAC coefficient covariance matrix automatically determines optimised lag structuring using Akaike information criterion (AIC). Kernel bandwidth is automatically determined using Andrew's AR(1) method and uses quadratic-spectral kernels. The break specification is sequential, testing the null of ℓ versus the alternative of $\ell + 1$ breaks. The information criterion is set to allow a maximum of 18 structural breaks, employs a trimming percentage of 5%, and significance at $p \leq 10\%$. The value-weighted returns of the energy sector ($\boldsymbol{R_{util}}$) is used as the dependent variable. The eight risk factors include: market premium ($\boldsymbol{R_{m,t}}$), local size premium ($LSMB_t$), local value premium ($LHML_t$), local momentum premium ($LUMD_t$) term premium ($\boldsymbol{R_{tp,t}}$), oil risk ($R_{o,t}$), coal risk ($R_{c,t}$) and gas risk ($R_{g,t}$). The intercept and error is denoted α_i and $e_{util,t}$, respectively. A ****, ***, ** or * denotes significance at 0.1%, 1%, 5% or 10%, respectively. The specification used is:

$$\boldsymbol{R}_{util,t} = \alpha_i + b_i\boldsymbol{R}_{m,t} + s_iLSMB_t + h_iLHML_t + m_iLUMD_t + tp_i\boldsymbol{R}_{tp,t} + o_iR_{o,t} + c_iR_{c,t} + g_iR_{g,t} + \ e_{util,t},$$

Partition	**Start**	**End**	α_i	b_i	s_i	h_i	m_i	tp_i	o_i	c_i	g_i	*Obs*	$\boldsymbol{R^2}$	$\boldsymbol{F}$	***Sig.***
1	01/07/1996	31/08/1998	0.0001	0.6084 ****	-0.2877 ****	0.0262	0.1097 ****	0.1037	-0.0038	-0.0339 **	0.0035	566	0.8042	228.59	****
2	01/09/1998	29/03/2000	0.0001	0.3011 ****	-0.6225 ****	0.0905 **	-0.0423	0.0194	-0.0109	0.0070	0.0058	412			
3	30/03/2000	07/09/2001	0.0003	0.2759 ****	-0.3497 ****	-0.0849 **	0.0727 *	0.0493	0.0159	0.0078	-0.0076	377			
4	10/09/2001	31/08/2004	0.0001	0.4956 ****	-0.3391 ****	-0.0416 *	-0.0784 ****	0.3948 ***	-0.0109	-0.0301 **	0.0019	777			
5	01/09/2004	24/07/2007	0.0004 ***	0.7495 ****	-0.1390 ****	-0.0705 ****	0.0655 **	0.0506	0.0218 **	-0.0088	0.0028	755			
6	25/07/2007	17/06/2008	0.0007	0.6502 ****	-0.3026 ***	-0.0187	0.0828 *	0.3420	0.1284 ***	-0.0215	-0.0004	235			
7	18/06/2008	27/04/2009	-0.0010	0.5448 ****	-0.4062 ****	-0.5345 ****	-0.0088	0.5015	0.0004	-0.0331 *	0.0093	224			
8	28/04/2009	31/01/2011	-0.0010	0.6914 ****	-0.2985 ****	-0.1402 ****	-0.1297 ****	0.4890	0.0094	-0.0288 **	-0.0088	460			
9	01/02/2011	28/06/2013	-0.0001	0.7964 ****	-0.2577 ****	0.1394 ****	-0.1270 ****	-0.1037	-0.0063	-0.0061	0.0048	629			

Similar to the annual regressions, the results of the partial break point tests show that the market beta is increasing towards unity through time with some fluctuation, indicating increasing systematic risk. Between 1998 and 2007, the market beta increases from 0.33 to 0.75. The upward shift in market beta, occurring late-2004, is consistent with that observed in Sections 4.3.2.2 and 5.4.2.2. The size premium coefficient (s_i) is consistently negative, indicating that the average returns in the energy utility sector behave like big energy utilities, with a greater impact in partition 2 (September 1998 to March 2000) and partition 7 (June 2008 to April 2009). The greater impact in 2008 onwards is of concern, as liberalisation objectives were introduced to counteract market dominance from big utilities (see Section 2.2.1); this negative s_i coefficient suggests the regulations were ineffective. The value premium coefficient (h_i) shows that average returns in the energy sector mostly behave like low-BE/ME (growth stocks). However, there are two partitions where average returns behave like high-BE/ME (value) stocks: partition 2 (September 1998 to March 2000) and partition 9 (February 2011 to June 2013). The partial break point test shows that average returns in the energy sector are explained by both upper and down momentum over time. Energy utilities behave like down-momentum stocks in partition 4 (September 2001 to August 2004) and partitions 8 and 9 (April 2009 onwards). There is a clear shift in the risk profile of energy utilities from 2009 onwards (beyond macroeconomic risk factors). Similar to the inter-temporal analysis of Section 5.4.2.2, after 2009 the sector is characterised by big, high-BE/ME, down momentum utilities which are taking on increased systematic risk. Chapter 6 will examine if liberalisation and environmental objectives are the cause for this negative impact on financial return.

Regarding the term premium and commodity risk factors, the results also show changing significance through time. Term premium becomes temporarily significant in partition 4 (September 2001 to August 2004), which encompasses the second packages of liberalisation and the lead up to the GFC, indicating a significant relationship between borrowing costs and returns. Oil price risk shows increased significance immediately before the GFC, showing that returns in the energy sector were highly sensitive to oil price risk. Coal price risk has sporadic significance across time which continues to be negative (when significant). Natural gas price risk continues to be insignificant through time, again, indicating effective hedging strategies. The differences between these results and the deductive method of Table 5.8 are manifestations of Quandt’s (1960) criticisms: unless the break points are known with certainty, the significance tests and estimated coefficients are likely to be biased.

The following section addresses analytical focus 4 of this chapter, examining the isolation of the firm-specific component of returns. This is achieved through the use of the local AFFM and the inductive structural break point tests.

5.4.2.4 Regression residuals and isolating the firm-specific returns

The regression results of this chapter can be used in applications that require estimates of expected stock return, including 1) portfolio selection, 2) evaluating portfolios performance, 3) estimates of cost of capital and 4) measuring abnormal return in event studies (Fama and French, 1993). Specifically, Chapter 6 of this thesis utilises the latter, performing an event study analysis on key stages of the European ordinary legislative procedure and examining abnormal returns induced by four distinct restructuring streams. One method includes extracting the residuals from a regression, for example, the unconditional CAPM, where the residuals are assumed to be the unsystematic, or firm-specific, component of returns (Chan et al., 1985, Fama and French, 1993). However, any omitted variables from the model specification will bias the estimates of regression coefficients, while inter-correlated disturbances will bias standard errors; both result in false positive, a spurious effect of regulation. The results of this robustness check will help identify a suitable method isolating the firm-specific component of returns for analysing abnormal returns in Chapter 6, or more generally. Accordingly, this section addresses analytical focus 4 of the chapter.

Typically, the three- and four-factor models capture common returns across a variety of stocks and are better at isolating the firm-specific components of returns (Fama and French, 1993). Chapters 4 and 5 also showed that term premium and commodity risk factors also have some impact on equity returns too, but are sensitive to the stock market risk factors specified. The assumption that these parameters are stable can result in spurious significant correlations between residuals and exogenous risk factors. Fama and French (1993) have also drawn inferences based on this fallacy, performing residual diagnostic tests with constant slopes; however, the authors acknowledge that the assumption on constant slopes may be a misconception but do not investigate the claim further. The following paragraph demonstrates the consequences of this erroneous assumption.

The residuals of the local AFFM model are extracted using three different methods, including: 1) the assumption of constant parameters in the unconditional local AFFM regression of Table 5.5 – similar to Fama and French (1993); 2) the time-varying parameters of the conditional annual local AFFM regressions in Table 5.8 – similar to the El-Sharif et al. (2005), who did not perform additional residual diagnostic tests; and 3) time-varying parameters of the local AFFM sequential break point test in Table 5.10 – based on the minimisation of the SSR from Bai and Perron (2003). The latter two assume time-varying parameters.

The cumulative and daily residuals through time are shown in Figure 5.7. The first observation is that the residuals of method (1), the unconditional constant parameter assumption, differ greatly from the other two, time-varying assumption – methods (2) and (3). For method (1), the assumption of constant parameters results in the cumulative residuals for energy utilities reaching 200% by mid-2008. The first invalid inference would be that this represents a firm-specific component to returns, increasing from 2003 to the GFC, and decreasing thereafter. It could be hastily concluded that this represents a structural break after the second packages of liberalisation (2003), expected to be a major regulatory event (see Section 2.1.1). Further, empirical tests will also identify significant breaks in returns which coincide with such an interpretation, in 2003 and 2008, as shown in Table 5.11.

TABLE 5.11: BAI AND PERRON (2003) BREAK POINT TEST

This table presents the results of the Bai and Perron (1998; 2003) sequential multiple 'pure' break point tests. The HAC coefficient covariance matrix automatically determines optimised lag structuring using AIC. Kernel bandwidth is automatically determined using Andrew's AR(1) method and uses quadratic-spectral kernels. The break specification is sequential, testing the null of ℓ versus the alternative of $\ell + 1$ breaks. The information criterion is set to allow a maximum of 18 structural breaks, employs a trimming percentage of 5%, and significance at $p \leq 10\%$. The mean equation only includes the constant as a regressor.

Method	Partition	Start	End	α_i	Sig.	$adj.R^2$	$F =$	Sig.
(1) Unconditional regression	1	01/07/1996	29/10/2003	0.0000		0.61%	13.69	****
	2	30/10/2003	09/06/2008	0.0006	****			
	3	10/06/2008	28/06/2013	-0.0006	***			
(2) Conditional annual regressions	1	01/07/1996	28/06/2013	0.0000		00.00%	-	-
(3) Sequential break points	1	01/07/1996	28/06/2013	0.0000		00.00%	-	-

Although the structural breaks are significant, the adjusted R^2 shows that these breaks explain a small proportion of the variation in the residuals, the FVU. In contrast to the significant structural breaks in the unconditional method (1), the time-varying methods (2) and (3) find no structural breaks. How can this result be reconciled? This chapter posits that the residuals of the unconditional approach in method (1), in fact, contain systematic risk factors beyond the firm-specific components of returns. This chapter also posits that the residuals reflect the changing relationship between the stock returns and the risk factors. This can be demonstrated in two ways. First, the time-varying methods, (2) and (3), both allow the risk factors to vary across time, capturing parameter shifts. Table 5.11 and Figure 5.7 show that the residuals in these two methods fall close to zero, suggesting few impacts from factors beyond those specified in the mean equation. Second, the expectation is that the residuals of the unconditional regression should have filtered out the impact of all risk premia, leaving an *orthogonalised* return series which represents *only* the firm-specific element of returns.

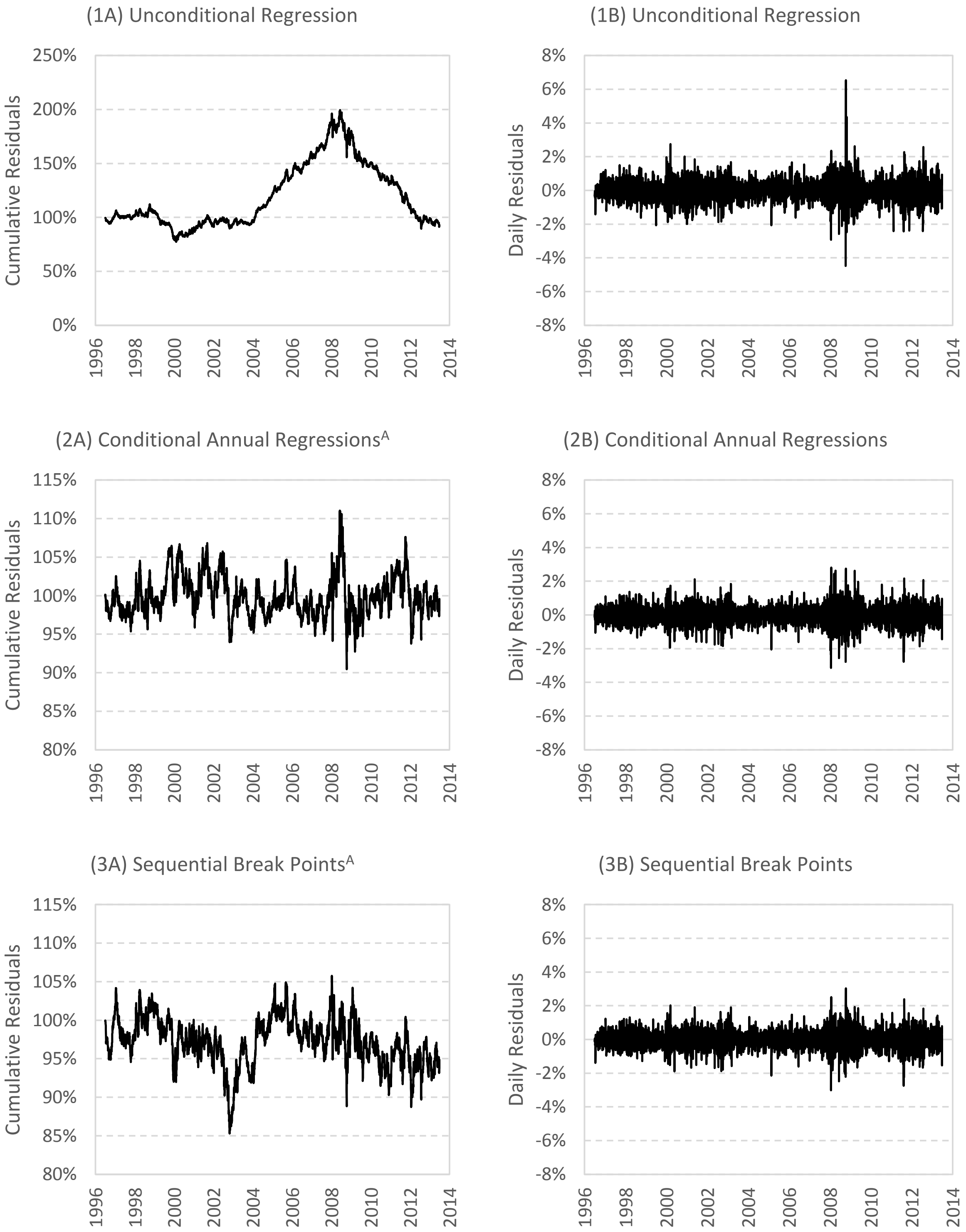


Figure 5.7: Cumulative and Daily Residuals of Regression Specifications

This figure illustrates the daily and cumulative residuals of three different local AFFM specifications: 1) the unconditional local AFFM (Plots 1A and B), the conditional annual local AFFMs (Plots 2A and 2B) and the sequential structural break point tests (Plots 3A and 3B).

[A] Note, vertical axis intentionally truncated between 80% and 115%. This is not intended to misrepresent data, but designed to better visualise the small differences between Plots (2A) and (3A). For both methods (2) and (3), the cumulative residuals fluctuate close to 100%, making the results barely indistinguishable when *y* axis begins at zero.

A second pass of the unconditional residuals in method (1), using either linear regressions or sequential break points model specifications, is expected to have no relationship with the risk factors, as they should have been filtered out in the first pass. However, this is not the case. To demonstrate, a second sequential break point test is employed on the unconditional residuals of method (1) against the market factor, local stock market risk factors, term premium and commodity risk factors; results are shown in Table 5.12. The first observation is the presence of significant relationships between the unconditional residuals and the risk factors. The adjusted R^2 shows that the unconditional full-period regression is insufficient at removing the risk premia, explaining 27.95% of residual variation, the FVU. The economic rationale is simple, a linear relationship is insufficient to capture time-varying common risk over long horizons; the polygonal approach of Bellman and Roth (1969) and Bai and Perron (2003) is able to control for the non-linearity and partial breaks across time.

The dates of the sequential break points in Table 5.12 are identical to those in Table 5.9 and Table 5.10, giving confidence that the residuals are capturing a shift in the relationship with risk premia. The estimated coefficients in Table 5.12 represents the difference between the estimated coefficients of the unconditional, full-period local AFFM (Table 5.5) and the estimated coefficients of the local AFFM break point regression (Table 5.10). Put simply, the estimated coefficient in Table 5.12 represent the *increasing* or *decreasing* relationship between average returns and the risk premia during the partition. For example, the long term market beta in Table 5.5 (also shown in Table 5.12) is 0.6306, while partition 2 of Table 5.12 estimates that the market beta experienced a statistically significant *downwards* shift of -0.3297, providing an overall market beta of 0.3009. Allowing for rounding, this value matches the estimated market beta of partition 2 in Table 5.10. In fact, the difference between each coefficient in Table 5.12 and the unconditional estimate equals the coefficient in Table 5.10.

TABLE 5.12: SECOND-PASS SEQUENTIAL BREAK POINT TEST ON RESIDUALS

This table presents the results of the Bai and Perron (2003) sequential multiple partial break point tests on the residuals of the constant slope regression. The HAC coefficient covariance matrix automatically determines optimised lag structuring using AIC. Kernel bandwidth is automatically determined using Andrew's AR(1) method and uses quadratic-spectral kernels. The break specification is sequential, testing the null of ℓ versus the alternative of $\ell + 1$ breaks. The information criterion is set to allow a maximum of 18 structural breaks, employs a trimming percentage of 5%, and significance at $p \leq 10\%$. The residuals of the constant slope regression is used as the dependent variable. The eight risk factors include: market premium ($\boldsymbol{R_{m,t}}$), local size premium ($LSMB_t$), local value premium ($LHML_t$), local momentum premium ($LUMD_t$), term premium ($\boldsymbol{R_{tp,t}}$), oil risk ($R_{o,t}$), coal risk ($R_{c,t}$) and gas risk ($R_{g,t}$). The intercept is denoted α_i. A ****, ***, ** or * denotes significance at 0.1%, 1%, 5% or 10%, respectively. The specification used is:

$$\boldsymbol{e_t} = \alpha_i + b_i\boldsymbol{R}_{m,t} + s_i LSMB_t + h_i LHML_t + m_i LUMD_t + tp_i\boldsymbol{R}_{tp,t} + o_i R_{o,t} + c_i R_{co,t} + g_i R_{g,t} + \ \mu_t.$$

Where μ_t represents the true firm-specific component of returns.

Partition	**Start**	**End**	α_i	b_i	s_i	h_i	m_i	tp_i	o_i	c_i	g_i	***Obs***	***Adj. R^2***	***F***	***Sig.***
1	01/07/1996	31/08/1998	0.0000	-0.0223	0.0097	0.1233 ****	0.1756 ****	0.1037	-0.0140	0.0032	0.0008	566	27.95%	22.50	****
2	01/09/1998	29/03/2000	0.0000	-0.3297 ****	-0.3251 ****	0.1877 ****	0.0237	0.0194	-0.0211 *	0.0441 **	0.0031	412			
3	30/03/2000	07/09/2001	0.0002	-0.3549 ****	-0.0523	0.0123	0.1387 ****	0.0493	0.0057	0.0449 *	-0.0104	377			
4	10/09/2001	31/08/2004	0.0000	-0.1351 ****	-0.0417	0.0555 **	-0.0125	0.3948 ***	-0.0211 **	0.0070	-0.0008	777			
5	01/09/2004	24/07/2007	0.0003 **	0.1188 ****	0.1584 ****	0.0267	0.1315 ****	0.0506	0.0116	0.0283 ***	0.0000	755			
6	25/07/2007	17/06/2008	0.0006	0.0195	-0.0052	0.0784	0.1487 ***	0.3420	0.1182 ***	0.0155	-0.0031	235			
7	18/06/2008	27/04/2009	-0.0011	-0.0859 **	-0.1089	-0.4373 ****	0.0571	0.5015	-0.0098	0.0040	0.0066	224			
8	28/04/2009	31/01/2011	-0.0011	0.0607 **	-0.0012	-0.0431	-0.0638 **	0.4890	-0.0008	0.0083	-0.0115 **	460			
9	01/02/2011	28/06/2013	-0.0002	0.1657 ****	0.0396	0.2366 ****	-0.0611 **	-0.1037	-0.0165	0.0310 **	0.0021	629			

Estimated AFFM coefficients extracted from Table 5.5.

α_i	b_i	s_i	h_i	m_i	tp_i	o_i	c_i	g_i
0.0001	0.6306 ****	-0.2975 ****	-0.0973 ****	-0.0661 ****	-0.0430	0.0103	-0.0370 ****	0.0028

This has implications for Chapter 6 as it suggests that the econometric approach adopted must control for time-varying risk parameters, as the residuals of the unconditional regression still contain risk premia, failing to accurately represent the firm-specific component of returns over long horizons. Appendix E develops this proposition further and shows, algebraically, that a fraction of variance unexplained (FVU) in the unconditional residuals can be accounted for by the changing relationship with the risk premia. These results show that the method of analysis of Chapter 6 must control for this changing relationship with premia over time to better isolate the firm-specific component of returns, necessary to calculate abnormal performance as a result of regulatory changes. Further, Appendix E examines the presence of January seasonals in the time series of this chapter which can also affect residuals.

The overall results indicate that structural break points in parameters, previously ignored in the unconditional model assuming constant slopes, account for around 28% of the residuals which were previously assumed to be the firm-specific element of excess returns. The benefit of the above analysis is twofold. First, this chapter demonstrates that the sequential partial break point approach has much greater ability to filter out systematic elements of returns. This method will better isolate the firm-specific component of returns, addressing analytical focus 4 of this chapter. Second, the results in Table 5.10 and Table 5.12 show that there are significant structural breaks in returns across time, primarily caused by changing relationships with the systematic risk factors. In fact, the only time period when energy utilities generated abnormal returns above their equilibrium values was partition 5. During partition 5, the intercept of the model shows that energy utilities generated an abnormal return of 0.03% per day between 2004 and 2007. This is the period preceding the GFC and is consistent with the rapid increase in returns observed in Figure 4.1 and Figure 5.2. The following section concludes the chapter.

5.5 Conclusion

This chapter focused on refining the global AFFM of Chapter 4 for sector level analysis to allow for a more nuanced understanding of the impact of risk factors on sector returns. This is achieved through the four analytical foci of the chapter, namely: 1) refining the global AFFM developed in Chapter 4 by calculating stock market risk factors at the sector level, creating a local AFFM; 2) applying the local AFFM to the sub-group portfolios of European utilities so as to explore within-sector heterogeneity; 3) applying inductive rather than deductive structural break point tests; and 4) better isolating the firm-specific component of returns. For each analytical foci of the chapter, the main results are as follows.

For analytical focus 1, the use of local stock market risk factors, specific to the energy utility sector, improves the performance of the global AFFM developed in Chapter 4. The global AFFM of Chapter 4, which calculated global stock market risk factors across a diversified sample of European stocks (see Section 4.2.4), resulted in an adjusted R^2 of 68.79%. In contrast, this chapter utilised the local AFFM, calculating local stock market risk factors which are specific to European energy utilities. The results showed that the local AFFM increased adjusted R^2 to 72.77% for the energy sector. Overall, the results showed that the local AFFM captures a greater proportion of sector level returns. Further, the use of local stock market risk factors allowed examination of returns at the energy sector level,

Addressing analytical focus 2, the local AFFM showed substantial heterogeneity across the 12 energy portfolios tested. First, the spread in estimated coefficients showed that the heterogeneous sensitivity to size, value and momentum premia were the largest determinants for the differences in expected returns across various energy portfolios; expected returns varied by 4.60-8.48% per annum between portfolios. In contrast, term premium and commodity risk factors showed relatively little impact, with the difference in expected returns across portfolios all being less than 0.87% per annum.

The third analytical focus concerns the use of the deductive conditional annual regressions and the inductive Bai and Perron (1998; 2003) structural break point tests (see Section 3.3.4). The annual regressions, using the local AFFM, resulted in a mean adjusted R^2 of 74.52%. The inductive method improves the local AFFM's goodness of fit further, producing an adjusted R^2 of 80.42%. The interpretations of the time-varying methods were qualitatively the same. The energy sector's market beta has been increasing towards unity through time, suggesting the sector is taking on increasing systematic risk. The size premium coefficient indicates that market returns of big utilities continue to dominate sector returns, suggesting that liberalisation objectives have been relatively ineffective. While the sector mostly behaves like growth utilities, from 2011 to 2013 the energy sector behaves like distressed utilities, with the latter two years being statistically significant. Momentum coefficients show significant and negative momentum in the years following major regulatory changes. In particular, the third packages of liberalisation in 2009 have resulted in persistent negative performance, consistent with the decline in market capitalisation observed in the following years. Term premia and commodities show sporadic significant though time, with coal and oil being the most important two commodities in explaining sector returns.

Finally, analytical focus 4 explores the isolation of the firm-specific component of returns using the residuals of the unconditional regressions, conditional annual regressions and inductive structural break point test. This chapter demonstrates that the common method of isolating the residuals of the unconditional regressions, such as the method implemented by Fama and French (1993), performs poorly at capturing the firm-specific components of returns. This chapter shows that structural breaks in the residuals of an unconditional regression correlate with structural breaks in the relationship between sector returns and risk premia. Using the unconditional local AFFM and the Bai and Perron (1998; 2003) structural break point regression, and specific to this chapter's energy sample and time period, the results show that 28% of the residuals variance is related to the changing relationship between sector returns and risk factors. The results of this chapter influenced the econometric approach adopted for Chapter 6.

5.5.1 Contributions

The results of this chapter make both academic and policy contributions. The following outlines the academic contributions. First, by demonstrating that the local stock market risk factors capture a greater proportion of returns relative to global stock market risk factors, this chapter shows that there is greater informational content *within* a sector, compared with informational content across an entire market. This approach helps improve the accuracy of estimated coefficients with regard to risk premia in the energy utility sector, which can be used in a variety of scenarios which require estimates of expected stock return (see Section 5.4.2.4). More generally, this chapter suggests an approach to developing a sector-specific asset pricing model and shows that local models explain a greater proportion of sector returns in comparison with inter-sectoral global models. Further, this chapter introduces industry portfolios and allows for portfolio rebalancing, an improvement over Oberndorfer (2009a) and Koch and Bassen (2013). Portfolio rebalancing is important in the case of mergers and acquisitions which can affect operations.

Second, the combination of the local AFFM and 12 energy portfolios (see Section 5.3.2.1) enabled a detailed examination of sector level returns and within-sector heterogeneity. As noted in the introduction to this thesis (Section 1.5), an asset pricing test which includes stock market risk factors has not been conducted in the European energy utility sector, addressing the avenue for further research previously highlighted by El-Sharif et al. (2005) and Oberndorfer (2009a). The results show that the risk profiles of energy utilities vary dramatically depending on firm characteristics. The ability to detect commodity risk across a variety of energy portfolios suggests that the portfolios have not fully realised the benefit of commodity risk hedging or find hedging difficult.

Third, this chapter extends the asset pricing literature by including modern advances from the econometrics literature, namely, the Bai and Perron (1998; 2003) inductive structural break point test. The Bai and Perron (1998; 2003) tests are utilised in two ways: 1) as a post-hoc stability diagnostic tool and 2) as a break point regression. The latter test can be used to explain evolving relationships between sector returns and risk factors through time and avoids many of the econometric criticisms of deductive break point tests (see Section 3.3.4.1).

Fourth, this chapter demonstrates that residuals of an unconditional regression, which were previously thought to be the firm specific component of returns, continue to retain systematic risk factors. The inference of this result is that failure to control for this time-varying nature of model parameters forces the systematic risk into the model’s residuals. This chapter demonstrates a method of utilising conditional annual regressions or an inductive break point regression to better isolate the firm-specific component of return and construct an orthogonalised firm-specific return series. This method of application is novel and makes a large contribution to the asset pricing literature in terms of identifying unsystematic, firm-specific components of return. Moreover, this chapter provides a flexible tool which can be adapted to other sectors, since it suggests a method of more accurately examining time-varying risk premia and isolating the firm-specific component of returns for any sector.

The following outlines the policy contributions. As a corollary to the second academic contribution above, the results of this chapter show heterogeneity of risk factors in the energy utility sector based on firm characteristics. Regarding the size portfolios, small utilities have lower systematic risk than big energy utilities, but have greater commodity risk exposure which implies that small utilities have not fully utilise the benefits of commodity hedging. As highlighted in Section 3.2.2.1, Chan and Chen (1991) argued that the small size quintile captures ‘fallen angels’ and marginal firms. It is possible that the small energy utility portfolio is also capturing these poorly performing utilities. This would be consistent with the significant value premium for small utilities, which shows that small utilities are also distressed firms. Further, it may indicate that small utilities are, for a variety of reasons, unable to access derivative markets for commodity hedging, or lack the capital or expertise to hedge effectively. It could also show that commodities play a key role as an indicator for energy price developments when valuing informationally sparse stocks, such a small utilities; see Kumar (2009) and Oberndorfer (2009a).

Regarding the industry portfolios, the electricity industry has greater cumulative returns than other industry portfolios, suggesting a greater risk-return relationship. The local AFFM shows that the electricity industry is distressed relative to other utilities, which is argued to be the impact of regulations relating to competition and renewables. The electricity industry is also taking on increasing commodity risk; again, suggesting a failure to effectively hedge commodity risk. While most portfolios performed like down momentum utilities, the natural gas industry is the only portfolio with positive momentum, possibly indicating excess profiteering. The natural gas sector also showed greater similarity with the oil & gas sector of Chapter 4, likely due to integrated and overlapping operations and the lack of 'pure' natural gas firms; congruent with Oberndorfer (2009a). Interestingly, the multi-utilities showed one of the lowest cumulative abnormal returns across all portfolios – indicating a lower risk-return relationship. The multi-utilities have less commodity risk exposure than both the natural gas and electricity industries, indicating economy of scope – diversified operations allow multi-utilities to switch operations when faced with regulatory changes or fluctuations in commodity prices.

More importantly, the policy implications above show that the energy sector's coverage in press has been subject to focalism. Many commentators, such as The Economist (2013a, b, c, 2015) and The BBC (2013), use case studies of big, natural gas utilities to exemplify perceived excess profiteering and highlight the impact of renewables and regulatory changes on the European energy utility sector. In particular, competition and renewable objectives have been a topic of intense debate in recent years. Liberalisation and environmental objectives in Section 2.2 are designed to counter market dominance from big utilities and reduce the EU's reliance on hydrocarbons. Naturally, the market is expected to devalue big, natural gas utilities which lose market dominance and revenue stream. The error of press is extrapolating these impacts to the energy sector as a whole. Such a narrow view ignores the growth opportunities afforded to small utilities through removal of national borders, or potential increase in demand for electricity utilities from the electrification of the transport sector. While focusing on risk exposure, the local AFFM and portfolio approach of this chapter has shown that there is substantial heterogeneity across various energy utilities.

5.5.2 Limitations

The major limitation of the thesis so far, and alluded to in the preceding section, is that the empirical chapters' contributions have primarily focused on developing the AFFM for European energy utility stocks; there has been no explicit examination or treatment of policy. The asset pricing models have only shown large changes in systematic risk which coincide in close proximity to known major regulatory changes. Thus, there has been no formal examination of the ordinary legislative procedure (Section 2.1), the broad range of restructuring events between 1996 and 2013 (see Table 2.1), and the four distinct restructuring streams (Section 2.2). To this end, Chapter 6 utilises the local AFFM to conduct an event study analysis of the timing of market reaction during the ordinary legislative procedure and examines the differential impact of the four distinct restructuring streams on abnormal returns.

CHAPTER 6

THE IMPACT OF REGULATORY CHANGES IN ENERGY UTILITY RETURNS

6.1 Introduction

As noted in Section 1.1, commentators have argued that renewable energy objectives have negatively impacted the valuation of the EU energy utility sector. However, the impact of regulations beyond renewables, which may also be responsible for affecting sector valuation, are rarely considered. For example, the EU's efforts to create a single European energy market through liberalisation legislation has transformed the energy sector from one largely dominated by state owned enterprises, with vertically integrated structure and regional monopolies, to an unbundled, competitive, privately-owned energy sector (see Section 2.2.1). Another major EU-led reform thrust that has built up particular momentum over the last decade is related to the environmental objectives of the sector and the 'greening' of the energy supply. This has focused on reducing energy demand through legislation promoting energy efficiency and renewable energy objectives (see, respectively, Sections 2.2.2 and 2.2.3). In addition to the liberalisation and environmental policies, energy utilities have also been subject to a range of legislation related to security of supply (see Section 2.2.4). Further, as was noted in Section 2.1, these policies are subject to protracted and complex legislative processes. This leads to two questions which are explored in this chapter: 1) At what stage of the ordinary legislative procedure do investors incorporate information about regulatory change? 2) How have these regulatory changes impacted the financial returns and valuation of EU energy utilities? With respect to the latter question, corollary questions concern the relative impact of the four policy streams (liberalisation, energy efficiency, renewables and security of supply) on returns and whether the policy streams have differential impact on firms (i.e. does the heterogeneity apparent in Chapter 5 expend to policy impacts).

If EU policies significantly impact the valuation of European utilities this can, in turn, affect utilities' cost of capital and capital-raising ability, as investors may require greater returns on investment in terms of dividends. As is well known, policy makers are asking utilities to increase their use of green-energy technologies and to make investments in a smart, decarbonised energy grid – the EU transition is estimated to cost $2.2 trillion between 2014 and 2035 (IEA, 2014). Put differently, policies may conflict. For instance, liberalisation policies may negatively impact the valuation of utilities, which, in turn, makes it more difficult to meet ambitious 'green' investment targets.

This chapter makes both academic and policy contributions by building on the asset pricing models developed in Chapters 4 and 5. It utilises an event study approach to examine how the valuation of EU energy utilities has been impacted by the myriad of regulatory changes described above. To this end, the chapter tests five hypotheses, developed in Section 6.2. The first, concerns market efficiency. The latter four concern the four restructuring streams. As stated in Section 1.5, the chapter 1) uses a large sample of 88 European energy utilities which controls for survivorship bias, 2) compiles a broad range of 54 regulatory changes, extracted from European law archives (see Chapter 2 and Table 2.1) and 3) conducts the most extensive test of the timing of information incorporation regarding European regulatory changes between 1996 and 2013. Only two papers have addressed related issues in the context of European energy utilities (Oberndorfer, 2009a; Koch and Bassen, 2013); however, no known paper has explored the magnitude and impact of the four restructuring streams over this period on such a large sample (see Section 3.2.3.3). As such, this chapter represents the most thorough investigation to date of the policy implications of the evolving financial return of European energy utilities.

In terms of academic contribution, this chapter examines the timing of market reaction surrounding key stages of the ordinary legislative procedure (see Section 2.1), finding that market reaction generally occurs at the early voting stages of the legislative procedure. This suggests strong market efficiency and a rational response from market participants, who impound information into asset prices at the earliest available opportunity. From a policy perspective, this chapter also shows that the Internal Energy Market and Energy Efficiency stream have a significant impact across the entire energy sector, while the Renewable Energies and Security of Supply streams have limited, firm-specific impacts. More importantly, it shows that the impact of regulatory changes can be hetergeneic depending on the underlying firm affected. The following section developes the five hypotheses tested.

6.2 Research Hypotheses

6.2.1 Timing of Market Reaction

The first stage of the analysis identifies the timing of market reaction within the ordinary legislative procedure. Market efficiency, outlined in Section 3.3.1, argues that investors are expected to be rational, wealth-optimising individuals. Investors will revalue energy utilities' stocks today based on perceived changes to future cash flows as a result of regulatory changes (Schwert, 1981). When information is anticipated or becomes public knowledge, information is immediately impounded into stock prices; any sudden change in value implies that the market has changed its assessment of future cash flows (Klassen and McLaughlin, 1996).

The co-decision procedure, as shown in Figure 2.2, requires two political institutions, the European Parliament and the Council of the EU, to independently agree upon the Commission's legislative proposal for it to pass into law (see Section 2.1). The process can be protracted and complex, while informational content is continually diffusing into the market. Investors will use this information to determine the probability that a regulation will become law, continually adjusting the probability and adjusting asset prices accordingly (Schwert, 1981). In the case of the ordinary legislative procedure, there are four potentially important event dates, per legislative proposal. The four dates considered include the announcement of the 1st position, the announcement of the 2nd position, the signature date and the publication date (see Section 2.1).

The announcement of the 1st position represents the date at which the first political institution (usually the Parliament) has principally agreed upon or amended a legislative proposal. The announcement of the 2nd position represents the date at which the second political institution (usually the Council) has also principally agreed upon the legislative proposal (or prior amendments). The 2nd position represents the date at which it is known with certainty that a proposal will become law. This chapter posits that the market reaction will occur surrounding the announcement of these two positions. However, we temper this proposition with caution. As Schwert (1981) notes, the assumption of market efficiency does not imply that investors have perfect information or foresight regarding the future effect of a regulation. It is possible that the *ex-post* realised effect of the regulation is different to the *ex-ante*¸ anticipated effect. Further, investors often exhibit a lagged response for a variety of reasons, including investor inattention (Dyck and Zingales, 2003, Dellavigna and Pollet, 2009); investor bias, including overconfidence and self-attribution (Daniel et al., 1998, Hirshleifer, 2001); hard-to-value information, including hard (quantitative) and soft (qualitative) information (Demers and Vega, 2008, Engelberg, 2008, Kumar, 2009); and media coverage and bias (Solomon, 2012). Griffin et al. (2015) also argue investors may not respond to information for numerous reasons, including 1) remote and uncertain consequences for the firm regarding the long-term nature of increased investment risk, 2) the expectation of full mitigation from government policies or 3) the ability to mitigate risk individually. Moreover, in many cases, the agreed-upon text is not the finalised version. Accordingly, information may also be impounded into asset prices in the interim period between the 2nd position and the signature date or during the legal-linguistic finalisation phase at which the final interpretations, definitions and revisions of the text are made (see Section

2.1.5). While substantial changes are unlikely to be made at this point, it is important that the analysis can capture these effects.

To address these issues, and ensure completeness of the analysis, two further event dates are tested. The third event date, the signature date, represents the point at which the two institutions meet, at a pre-scheduled monthly meeting, to sign the agreed-upon legislation and the legislative proposal is formally adopted. The fourth event date, the publication date, represents the legislation's formal publication in *The Official Journal of the European Union*. As the informational content at the signature and publication dates is mostly unchanged (see Section 2.1.5), there should be little to no reaction at these later stages of the procedure. Further, as all events are public and scheduled, it is assumed that the market can coordinate their trading in anticipation of the outcome regarding the regulatory change. Accordingly, the first hypothesis which focuses on the timing of information in asset prices predicts:

H_1: *Significant market reactions to regulatory changes will predominantly occur in the early co-decision stages of the legislative procedure (i.e. 1st position and 2nd position dates).*

The null hypothesis is that there will be no significant reaction at the early co-decision stages of the procedure. The second set of hypotheses relate to the impact of each regulatory stream.

6.2.2 The Impact of the Four Restructuring Streams

Section 2.2 outlines the four distinct restructuring streams related to the regulation of the European energy utility sector. The first stream addresses liberalisation objectives of the energy sector, the Internal Energy Market stream (Section 2.2.1). The second and third streams address environmental objectives of the sector; the Energy Efficiency (Section 2.2.2) streams. The fourth stream focuses on security of the oil and energy supply in the EU, the Security of Supply stream (Section 2.2.4). The following paragraphs develop hypotheses for each stream.

Briefly, the liberalisation literature in Section 3.3.2 argued that deregulation of markets is expected to lower entry barriers, increase competition from large international competitors and expose energy utilities to the real threat of bankruptcy (Beneish, 1991, Gual, 1999, Megginson et al., 1994). Deregulation also brings additional expenses such as reorganisation costs, increased brand awareness and cutting unit costs to gain market share (Beneish, 1991, Gual, 1999, Nwaeze, 2000, Delmas and Tokat, 2005). Further, liberalisation is expected to increase revenue volatility through reducing the use of long-term contracts, while vertically unbundling utilities (see Section 2.2.1) is expected to reduce insurance against fluctuations in commodities and the buffering effect from cost and demand shocks (Beneish, 1991, Nwaeze, 2000, Jamasb and Pollitt, 2005). For the banking sector, Kane and Unal (1998) document increases in both systematic and unsystematic risk, an increased number of failed and problem banks and negative abnormal returns as a result of regulatory changes. Among other risk factors, Chapters 4 and 5 showed increasing systematic risk increasing firm distress and decreasing momentum through time (see Table 4.7 and Table 5.8, respectively).

The expectation is that the market will react negatively to the Internal Energy Market stream. Energy utilities now lose the natural regional monopolies and are now forced to compete on price and services with a large number of competitors. Accordingly, the second hypothesis is:

H_2: *Liberalisation objectives related to the Internal Energy Market stream will negatively impact the financial return and market value of energy utilities, in particular large incumbent utilities that have historically had market power.*

The environmental objectives are addressed through two streams the: Energy Efficiency and Renewable Energies streams. The environmental policy literature in Section 3.3.3 found mixed results with respect to the impact of environmental objectives on operating performance, which has implications on future cash flows. Some authors found that compliance with environmental regulations decreased productivity or argued that retrofitting existing energy plants is costly (Bragdon and Marlin, 1972, Gollop and Roberts, 1983). Further, the financial burden of environmental objectives means allocating resources away from other goals, including investment projects and plant upgrades (Walley and Whitehead, 1994, Dobes et al., 2014). In contrast, other researchers argued that environmental regulations can increase productivity, as it encourages firms to innovate, provides new market opportunities and encourages firms to make low-cost savings (Walley and Whitehead, 1994, Hart and Ahuja, 1996). Further, technological innovation, the social benefit of renewable energies and lower firm emissions may increase firm value as socially responsible investors reward these firms through increased investment (see Section 3.3.3.2). The likely impact of environmental objectives will depend on the informational content within the two distinct restructuring streams.

Section 2.2.2 addresses the Energy Efficiency restructuring stream specifically. To summarise, the Energy Efficiency stream focuses on reducing energy consumption from the most energy-intensive end-user appliances in the EU. Further, legislation also focuses on improving the energy efficiency of homes, with the objective of building carbon-zero homes by 2020. However, this must be balanced against population growth which is likely to increase energy demand. The overall impact is improved energy efficiency resulting in a decline in energy demand by about 10% to 20% (Delarue et al., 2011). The third hypothesis tested states:

H_3: *Environmental objectives related to the Energy Efficiency stream will negatively impact the financial return and market value of energy utilities across the entire sector since it reduces overall energy consumption.*

The second stream relating to environmental objectives is the Renewable Energies stream (see Section 2.2.3). As noted in Sections 1.2 and 2.2.3, renewable energy sources are afforded grid priority at the expense of combustion fuel generators. Grid priority has resulted in renewable energies being able to sell energy at the expense of combustion fuel generators. Renewable energy generators typically operate during peak hours, when the renewable energy sources are available, which have historically been the most profitable hours for combustion fuel generators. However, this intraday disadvantage must be counterbalanced by the second objectives of Renewable Energies legislation. The legislation also focuses on electrification of the transport sector, where at least 10% of transport must be electrified across all Member States by 2020. Importantly, the electrification of other sectors, such as transport, is expected to decrease energy demand for hydrocarbon sources (see Section 2.2.3). If there is to be any impact from the Renewable Energies legislation, the impact will predominantly have a negative impact on natural gas utilities through the decreased use of hydrocarbons. Electric utilities that are unable to adapt may also experience a negative impact, although this impact is expected to be smaller, as Söderholm (1998, 2001) reports short- and long-term fuel-flexibility in EU electricity generators (see Section 3.3.5.2). Therefore, the fourth hypothesis tested is:

H_4: *Environmental objectives related to the Renewable Energies stream will negatively impact the financial return and market value of energy utilities, in particular natural gas and hydrocarbon-intensive utilities.*

Finally, the fourth restructuring stream relates to securing oil and energy supply at EU-level. The Security of Supply stream focuses on diminishing the harmful effects from difficulties in securing crude oil and petroleum products; see Section 2.2.4. The overall objective is to provide authorities with powers to partially regulate oil prices in order to prevent abnormal price rises[31] and maintain sufficient oil and gas inventories to mitigate physical interruptions in supply and to use existing inventories strategically by giving energy utility companies priority with respect to the consumption of these reserves. Although the stream does not affect energy utilities directly, the impact is expected to affect oil prices. As argued by Huang et al. (1996) and Faff and Brailsford (1999), investors are expected to efficiently capitalise the cash flow implications of any industry which uses oil as an input or output to operations, or where oil is related to sector valuation. The existing literature in Section 3.2.3.2 and Table 3.1 showed that the majority of papers find a positive relationship between equity values and oil prices. The empirical evidence in Section 3.2.3.2 showed that decreasing volatility and/or declining oil prices negatively impact industries where oil is a major output, such as the oil & gas sector, mining and electricity industries (Scholtens and Yurtsever, 2012). Chapters 4 of this thesis showed that oil price risk has a positive relationship between oil and sector returns through time (see Table 4.7). Further, the differential impacts of oil on various portfolios of energy utilities in Chapter 5 are also mostly positive, with natural gas utilities having the greatest risk exposure (see Table 5.5). *A priori*, based on the expected positive relationship between sector returns and oil prices, regulations which prevent abnormal price rises should also negatively impact the energy sector. In particular, there should a large decline in the value of natural gas utilities. Accordingly, this chapter tests the following hypothesis.

H_5: *Measures to safeguard the European energy supply, related to the Security of Supply stream, will negatively impact the financial return and market value of energy utilities.*

In all cases, the null hypothesis is that there is no significantly impact from regulatory changes.

6.3 Methodology

In order to address the hypotheses developed above, this chapter adapts the local AFFM developed in Chapter 5 (see Section 5.3.3) using event study techniques. As stated in Section 3.2.2 and shown in Chapter 4, the inclusion of stock market risk factors typically explains a greater proportion of average stock returns compared with existing asset pricing models, congruent with Fama and French (1993). Further, Chapter 5 showed that the local versions of the stock market risk factors typically have greater regression fits and are better able to explain returns at local levels, congruent with Fama and French (2012). To explore this impact to its fullest extent, the tests are implemented on 12 energy portfolios outlined in Chapter 5 (Section 5.3.2.1) to examine within-sector heterogeneity of market reaction to the regulatory changes. The rest of this section expands on the research method implemented; the related sub-sections outline the models implemented and econometric approach (Section 6.3.1), the sample (Sections 6.3.2) and the list of regulatory events examined (Section 6.3.3).

6.3.1 Models and Econometric Approach

The impact of an economic event can be estimated by examining rates of return to shareholders of firms during a period of regulatory change (Schipper and Thompson, 1983). To assess the impact of a regulatory change, an event study approach is typically comprised of two parts, as shown in Figure 6.1: establishing normal returns over an estimation window, then measuring abnormal returns during an event window. Following MacKinlay (1997), returns are indexed in event time using τ, where $\tau = 0$ is defined as the event date. The event window is defined as $\tau = T_1 + 1$ to $\tau = T_2$, while $\tau = T_0 + 1$ to $\tau = T_1$ defines the estimation window. Let $L_1 = T_1 - T_0$ and $L_2 = T_2 - T_1$ be the length of the estimation window and the event window, respectively. The event study approach relies on the assumption that the event's impact is captured by the abnormal returns. Therefore, the estimation window and the event window cannot overlap, ensuring that the estimators for the parameters of the normal return model are not influenced by the returns around the event, which could significantly influence the normal return measure (MacKinlay, 1997). The following sub-sections outline the method of estimating normal return (Section 6.3.1.1) and the isolation of abnormal return surrounding a regulatory event (Section 6.3.1.2).

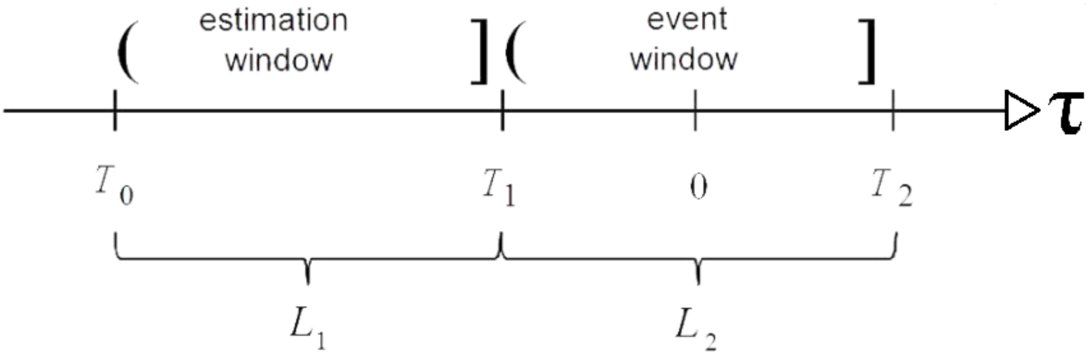


FIGURE 6.1: TIME-LINE OF AN EVENT STUDY APPROACH

This figure illustrates the time-line of an event study approach, relative to an event on day zero. The estimation window represents the period over which normal returns are established. The event window represents the period over which abnormal returns are measured, preceding and following an event. Figure adapted from MacKinlay (1997) and Event Study Metrics (2015)

6.3.1.1 Estimating normal returns

To establish normal returns over the event window, this chapter adopts an economic approach, as opposed to the statistical approach,[60] concerning investors' behaviour. The advantage of the economic approach is the more precise measure of normal return using economic restrictions (MacKinlay, 1997). The economic model implemented in this chapter is the local AFFM developed in Chapter 5 (see Section 5.3.3). The model specification is:

$$\begin{aligned}\boldsymbol{R}_{i,L_1} = \alpha_{i,L_1} + b_i\boldsymbol{R}_{m,L_1} + s_iLSMB_{L_1} + h_iLHML_{L_1} + m_iLUMD_{L_1} \\ +tp_i\boldsymbol{R}_{tp,L_1} + o_iR_{o,L_1} + c_iR_{c,L_1} + g_iR_{g,L_1} + e_{i,L_1}, \qquad (6.1)\end{aligned}$$

estimated over the estimation window (L_1) preceding each event window (L_2), see Figure 6.1, where: α_{i,L_1} denotes the intercept over L_1, b_i denotes the market factor coefficient, $\boldsymbol{R}_{m,L_1}$ denotes the excess return on the market factor over L_1, s_i denotes the $LSMB$ coefficient, $LSMB_{L_1}$ denotes the local size premium over L_1, h_i denotes the $LHML$ coefficient, $LHML_{L_1}$ denotes the value premium over L_1, m_i denotes the $LUMD$ coefficient, and $LUMD_{L_1}$ denotes the momentum premium over L_1, tp_i denotes the term premium coefficient, $\boldsymbol{R}_{tp,L_1}$ denotes the term premium over L_1, o_i denotes the oil price risk coefficient, R_{o,L_1} denotes the return on oil price over L_1, c_i denotes the coal price risk coefficient, R_{c,L_1} denotes the return on coal price over L_1, g_i denotes the natural gas price risk coefficient and R_{g,L_1} denotes the return on natural gas price over L_1. The restructuring events are listed in Table 2.1.

The estimation window (L_1) is set to 100 days. While MacKinlay (1997) recommends 120 days for daily data, the choice of 100 days was made as the first packages of liberalisation

---

[60] Statistical approaches include the *Constant Mean Return Model* and the *Market Model*, while economic approaches include asset pricing models such as CAPM, the four-factor model and, more generally, asset pricing models.

(see Section 2.2.1) occur 123 days after the beginning of the time series and is expected to be a major regulatory event – allowing a maximum estimation period of 103 days combined with a ± 20-day event window (discussed further below). The purpose of estimating the parameters prior to each window is a standard approach to estimating model parameters (Meznar et al., 1994, Agrawal and Kamakura, 1995, MacKinlay, 1997). Moreover, the method also accounts for the time-varying nature of risk factors observed in Chapter 5, Sections 5.4.2.2 and 5.4.2.3, giving a more precise estimation of risk premia and better isolating the firm-specific component of returns. Under general conditions, OLS is a consistent estimation procedure (MacKinlay, 1997).

There is often an inherent assumption of parameter stability with regard to an event study, which is problematic over long windows (McWilliams and Siegel, 1997). The approach of this chapter assumes short-term stability in the risk parameters, and extrapolates normal return over the event window of (up to) ± 20-days. Plot 2A and 3A of Figure 5.7 shows that the cumulative residuals of a time-varying approach rarely deviate from 100%, so this chapter can be reasonably certain of parameter stability in the short-term, for event windows less than 40 days.

Griffin et al. (2015) argue that the inclusion of variables, such as crude oil price changes, can result in both Type I and Type II errors. Including too many commodities can obscure some of the energy-related impacts the chapter seeks to identify, while excluding the commodities can incorrectly attribute market reactions to regulatory changes which are, in fact, commodity impacts. Table 3.1 and the results of Chapter 5 (Table 5.5) find significant commodity risk exposure within the energy sector. Oberndorfer (2009a) argues that investors may benchmark utilities prices against seemingly related commodities, using oil as a proxy for developments in the energy market as a whole. This econometric issue may be exacerbated when faced with uncertainty regarding regulatory changes. If true, then it is possible that commodities may lessen the abnormal return surrounding the regulatory change. Diagnostic tests in Section 6.4.3.2 will explore the influence of commodities and stock market risk factors on the abnormal return surrounding regulatory changes.

6.3.1.2 Isolating abnormal returns

If the regulatory event conveys information to investors, the underlying principle of the event study approach is that the impact on stock valuation will depend on the magnitude of the unexpected component of the regulatory change. As the normal return for a stock is defined as the hypothetical expected return without conditioning of the event occurring (MacKinlay, 1997), the measure of abnormal return is the actual *ex-post* return of the stock, during the event window, which is in excess of the normal return. Abnormal return is specified as:

$$AR_{i\tau} = R_{i\tau} - E(R_{i\tau}|x_\tau) \tag{6.2}$$

where $AR_{i\tau}$, $R_{i\tau}$ and $E(R_{i\tau}|x_\tau)$ are the respective abnormal, realised and normal (expected) returns for the i^{th} portfolio over the event period, τ, and x_τ denotes the conditioning information for the normal return. As stated in Section 6.3.1.1, the AFFM is used to estimate normal return in the estimation window and is extrapolated to the event window. The residuals of the model are forecast errors from the AFFM which correspond to conventional measures of abnormal returns (Schipper and Thompson, 1983). Econometrically, to measure abnormal returns of portfolio i, let $AR_{i\tau}$ be the sample of abnormal returns in the event window L_2. Abnormal return, with regard to event date τ, can be defined as:

$$AR_{i\tau} = R_{i\tau} - \hat{R}_{i\tau} \tag{6.3}$$

where

$$\begin{aligned}\hat{R}_{i\tau} = {} & \hat{\alpha}_{i,\tau} + \hat{b}_i\boldsymbol{R}_{m,\tau} + \hat{s}_i LSMB_\tau + \hat{h}_i LHML_\tau + \widehat{m}_i LUMD_\tau \\ & + \widehat{tp}_i\boldsymbol{R}_{tp,\tau} + \hat{o}_i R_{o,\tau} + \hat{c}_i R_{c,\tau} + \hat{g}_i R_{g,\tau}.\end{aligned} \tag{6.4}$$

The standard approach to exploring abnormal returns is to define the event window surrounding an event (see Figure 6.1) to be larger than the specific period of interest (Meznar et al., 1994). The purpose is to allow examination of periods surrounding the suspected event. This also captures the possibility of investors acquiring information prior to the actual announcement, any event effects which occur after stock market closes on announcement day or delayed impacts (MacKinlay, 1997). Section 2.1 highlights multiple points at which information may leak into the market early, while Section 6.2.1 highlights a variety of reasons why the market may exhibit a lagged response. Further, the protracted legislative procedure outlined in Section 2.1 shows that the legislative procedure is a multifarious process. Thus, the market reaction will depend on the type of legislation (regulation, directive or decision), the stream (see Section 2.2), the stage of the legislative procedure (see Section 2.1) or the type of firm likely to be impacted (see Section 5.3.2.1).

To this end, the research method tests a variety of event windows surrounding a proposed legislation, denoted (T_1, T_2) where T_1 denotes the beginning of the event window and T_2 denotes the end; see Figure 6.1. This chapter tests eight event windows, divided into three groups. The full event window, $(-20,20)$, test the impact over a long-horizon surrounding the event. Four short windows are tested, $(-20,-1)$, $(-10,-1)$, $(1,10)$ and $(1,20)$, which capture the impact in the weeks preceding or following the event – excluding the event date. Finally, three narrow windows $(0,0)$,$(-1,1)$ and $(-2,2)$ are tested to examine the impact immediately surrounding the event. Similar to Meznar et al. (1994) and Agrawal and Kamakura (1995), this chapter utilises the (T_1, T_2) convention when referring to specific event windows, and conducts significance tests over each event window (Section 6.4.2).

Because the event study is conducted over multiple events per portfolio, for various calendar dates, the abnormal returns observations can be aggregated across events (cross-sectionally) and through time (temporally) over the event period to construct inferences regarding the impact of events (Agrawal and Kamakura, 1995, MacKinlay, 1997). The analysis would otherwise exclusively focus on the event date itself and ignore any anticipation or lagged effects. The abnormal returns are transformed using two methods.

First, since the direction of price change is not specified in $\boldsymbol{H_1}$, an unsigned expectant model is implemented to examine return variance in the days surrounding the four key stages. Using Beaver's (1968) method, the abnormal returns are computed for each day during the event window T_0 to T_2 for each event. The average abnormal returns, cross-sectionally, is calculated for each day ($\overline{AR}_{i\tau}$). The average abnormal returns are squared ($\overline{AR}_{i\tau}^2$) and divided by the variance of the abnormal returns (s_i^2) during the estimation period (T_0 to T_1):

$$U_\tau = \frac{\overline{AR}_{i\tau}^2}{s_i^2} \tag{6.5}$$

where U_τ provides a ratio of return variance *within* the event window relative to the variance observed over the estimation period. When U_τ is 1, there's no change in volatility as $\overline{AR}_{i\tau}^2$ and s_i^2 are in parity.[61] If the legislation contain informational content, the return variance during the event window, $AR_{i\tau}^2$, greater than that observed during the estimation period, s_i^2. Accordingly, the ratio U_τ will be greater than parity (1).

Second, a modern event-study approach performs significance tests on cumulative average abnormal returns (CAARs), defined as:

$$CAAR_{i\tau} = \sum_{\tau=T_1}^{T_2} AR_{i\tau}, \tag{6.6}$$

where $CAAR_{i\tau}$ is the cumulative average abnormal return for portfolio i, over the event window T_1 to T_2, and $\overline{AR}_{i\tau}$ is the average abnormal return for portfolio i across all regulatory events tested. For the econometric results in Section 6.4.2, we test the null hypothesis that $CAAR_{i\tau} = 0$ during the eight event windows, against the alternative that cumulative returns

---

[61] Beaver (1968) provides no formal test of significance for U_τ. Accordingly, significant tests are included in the forthcoming CAAR analysis.

are significantly different from zero. The results identify whether the market reaction surrounding the regulatory event is significantly different from zero.

The CAARs will be used to answer the five hypotheses of this chapter. To test $\boldsymbol{H_1}$, CAARs surrounding the four key stages of the legislative procedure, across all legislation in Table 2.1, will be used to measure the timing of market reaction (see Section 6.2.1). To test $\boldsymbol{H_2}$ to $\boldsymbol{H_5}$, the CAARs are tested on all four stages of the legislative procedure, delineated into the four restructuring streams; see Section 6.2.2.

A variety of alternative significance test statistics for the CAAR and single-period AR have been developed over the years. Tests include the standardised abnormal residual test of Patell (1976) and Patell and Wolfson (1979), which tests the null that $\text{CAAR} = 0$. However, Boehmer et al. (1991) show that Patell's test is more likely to reject the null in cases where return variance increases around the event. Brown and Warner (1980) develop a cross-sectional t-test which is robust to event-induced increases in variance. Boehmer et al. (1991) combine elements of the previous two tests to develop a test which is robust to induced stock variance and based on a cross-section of event-window abnormal returns. Boehmer and Warner's (1991) test is generally superior to Brown and Warner (1980). The tests primarily focus on cross-sectional event studies, but have implications for time-series event studies too. While the discussion of significance tests is still ongoing, this chapter reports standard t-tests in line with similar event study papers, such as Klassen and McLaughlin (1996) and Griffin et al. (2015). This chapter mitigates the possibility of changing variance through time by controlling for heteroskedasticity using pre-Whitened residuals. The use of robust standard errors is recommended by Princeton University (2008).

The econometric analysis is performed in *STATA*, with an example of the command (.do file) provided in Appendix F. The framework of the *STATA* code is based on one outlined by Princeton University (2008), accommodating multiple events per portfolio, heteroskedasticity and (implicitly) time-varying risk parameters.

6.3.2 Sample

This chapter utilises the same 12 energy utility portfolios constructed in Chapter 5. The method of portfolio construction is outlined in Section 5.4.1.1. As Chapter 5 examines systematic risk and time-varying risk premia using the local AFFM, this chapter is a natural progression to examine the firm-specific component of returns. Further, this chapter examine within-sector heterogeneity of portfolios to various regulatory changes. Briefly, the analysis is conducted on the excess returns of 88 European energy utilities, operating in the electricity and/or natural gas industries. The energy utilities are grouped into 12 portfolios based on similarity of characteristics, namely: the energy utility sector as a whole, high-BE/ME, mid-BE/ME, low-BE/ME, upper momentum, medium momentum, down momentum, electric-utility, natural gas-utility, multi- utility and small and big energy utility portfolios.

6.3.3 Data

Regarding the data, this chapter also utilises the same data as Chapter 5, Section 5.3.2. Briefly, the STOXX® 600 Europe index is used as a measure of broad market returns. Local stock market risk factors are calculated using daily data, including size premium, value premium and momentum premium; see Section 5.3.3. Term premium and commodity risk factors (oil, coal and natural gas price changes) are also included in the analysis (see Section 4.2.3).

6.3.3.1 Measuring regulatory changes

The regulatory changes used in analysis are listed in Table 2.1, identified through chain sampling. This chapter constructs a broad range of regulatory changes to date. This is achieved by identify an overview[62] of EU energy utility legislation which is currently in force, produced by the Department (Directorate-General) for Energy (DG ENER), forming the initial sample of legislation. This sample is expanded further by extracting summaries[63] of energy-specific legislation from the *EUROPA* website, dedicated to archiving EU. Using *EUROPA*[64] and *The Official Journal of the European Union*, the list of legislation is expanded through chain sampling. Chain sampling includes searching *EUROPA* for all repeals, amendments and linked documents. As noted in Chapter 2, 54 eligible regulatory changes are identified, published over 45 unique dates between July 1996 and June 2013. The regulatory changes are categorised these into four streams (see Figure 2.3).

To test $\boldsymbol{H_1}$, the first stage of the event study will examine the timing of market reaction. As stated in Section 6.2.1, the four key stages tested include the 1st position, 2nd position, signature date and publication date. The dates for the key stages are obtained from the historical timeline of each legislation, outlined in the central European law archive (*EUROPA*)[65] and discussed in detail in Section 2.1. Typically, the EU Parliament announces their position first, while the Council of the EU announces their position second. Exceptions to this rule occur if either political institution amends the proposal. Of 54 pieces of legislation,

---

[62] *DG ENER*'s latest publication is available at: http://ec.europa.eu/energy/doc/energy_legislation_by_policy_areas.pdf [updated April 2014]

[63] http://eur-lex.europa.eu/summary/chapter/energy.html?root_default=SUM_1_CODED=18

[64] http://eur-lex.europa.eu/

[65] As noted in Section 2.1.4, the URL hyperlinks embedded in Table 2.1, for each legislation, show all of the key dates, documents and discussions regarding each piece of legislation. The information is freely available to any investor who wishes to find such information.

there are 32 events regarding the announcement of the 1st position, 34 events regarding the announcement of the 2nd position,[66] 44 events regarding a piece of legislation's signature date and 45 events regarding the legislation's publication date. The lower number of 1st and 2nd position is due to Commission Directives, which do not include the co-decision stage. The 1st position, 2nd position and signature dates were all located on trading days. For the publication dates, nine were located on non-trading days and therefore assumed to impact on the next trading day (Meznar et al., 1994).[67]

To address $\boldsymbol{H_2}$ through to $\boldsymbol{H_5}$, the second stage of the event study focuses on the four restructuring streams (see Section 2.2). For measures of regulatory changes regarding liberalisation objectives, all restructuring events relating to the Internal Energy Market, are included (see Section 2.2.1). In total, 19 pieces of legislation relate to liberalisation objectives. For measures of regulatory changes regarding environmental objectives, two restructuring streams are identified the: Energy Efficiency and Renewable Energies streams. The two are delineated due to their content (see Sections 2.2.2 and 2.2.3, respectively). The Energy Efficiency stream contains 27 pieces of legislation, while the Renewable Energies stream contains three. A miscellaneous category relates to the security of energy supply in the EU. The Security of Supply stream contains five pieces of legislation. The following section addresses issues regarding the event study approach.

6.3.3.2 Challenges arising from the data

As shown previously, the number of dates concerning the 1st and 2nd positions were lower than the number of signature and publication dates. This is the result of Commission Directives, which do not follow the standard co-decision process of the ordinary legislative procedure. Consideration was given to omitting these regulatory changes. However, upon inspection these included key regulatory changes, including establishing the regulatory agency EREG, strategic oil stocks and implementations of major Energy Efficiency legislation. These are expected to have a major influence on liberalisation and environmental objectives of the energy sector. Further, the Commission Directives focus on implementing the decarbonisation objectives, affecting underlying electricity demand and thus the electricity industry. The inclusion of these events represents the realistic impact of regulatory changes

---

[66] This is the result of one *Council* regulation and one *Council* directive – which differs from the ordinary legislative procedure. The 1st position of Council is implicitly a vote to adopt, while the 2nd position relates to the European Parliament's vote.

[67] This is standard practice if the event is to be included in analysis; further analysis shows that publication dates are relatively unimportant.

that energy utilities and investors would experience in the market. Therefore, the regulatory changes were included in the analysis.

The second research issue relates to confounding events, which, as Foster (1980) argues, can have a broad definition. This thesis defines confounding events as events from multiple streams occurring on the same day. Failing to control for confounding events can affect the validity of the empirical results and calls into question the true impact of each regulation on stock prices (McWilliams and Siegel, 1997, Konchitchki and O'Leary, 2011). The first step in a systematic approach is to document the number of potentially confounding events; the second step is to rank the events on importance. There are two overlapping streams in the list of regulatory changes, shown in Table 6.1. The third step is to adopt an experimental design to explicitly control for the confounding events.

TABLE 6.1: STREAM OVERLAPS

This table presents the confounding events, across all four key stages, from the 54 regulatory changes in Table 2.1.

	Overlap 1	**Overlap 2**
Date:	16 June 2003, 26th June & 15th July 2003	22 April 2009
Key Stage:	2nd Position, Signature date, & Publication Date	1st Position
Stream #1:	Internal Energy Market	Internal Energy Market
Content:	• Internal market for electricity (second package) • Internal market for natural gas (second package) • Cross-border exchanges in electricity • Trans-European energy networks	• Internal market for electricity (third package) • Internal market for gas (third package) • Establishing ACER • Cross-border exchanges in electricity • Conditions for access to natural gas networks
Policy Importance	High	High
Stream #2:	Energy Efficiency	Security of Supply
Content:	• “Intelligent energy for Europe” programme	• Minimum stocks of Crude oil and Petroleum products
Policy Importance	Mid	Mid

Foster (1980) suggests five methods to control for confounding events. From an econometrics perspective, consideration was given to the deletion method, omitting the confounding event entirely. However, this is a suboptimal approach and unpalatable from a policy perspective. In both circumstances, the Internal Energy Market stream overlaps with a neighbouring stream. Unfortunately, the contemporaneous observation includes the second and third packages of liberalisation (see Section 2.2.1), overlapping with a legislation from another stream. The second and third packages are the main catalysts for energy sector liberalisation. Of all the streams examined, the Internal Energy Market stream is expected to have greater policy importance. Thus, an alternative experimental design is necessary to fully examine the impact of liberalisation.

This thesis opts to adopt Foster’s (1980) third and fifth solutions. First, the analysis will continue assuming the confounding event has little to no impact. The argument for this approach is that each event is centred on day 0, creating a portfolio of abnormal returns which are averaged across all events; therefore, the net effect of the single confounding event will be minimal (Foster, 1980). The second approach is to delete an ‘appropriate’ time surrounding the confounding event. The diagnostic tests in Section 6.4.3.1 performs a separate analysis to examine to what extent the significance tests change when excluding the contemporaneous observations. This latter control of deleting observations surrounding the confounding event been adopted, or recommended, by Dyckman and Smith (1979), Meznar et al. (1994), McWilliams and Siegel (1997) and Konchitchki and O'Leary (2011). Overall, results of this chapter show little different in CAARs and significance tests.

A further anticipated criticism of the econometric approach is the possibility of event clustering (overlapping events). In reality, multiple legislation are concurrently being discussed, amended and voted upon. Table 6.2 shows that the mean lag between any two events is 29.6 days. While the 100-day estimation window and series of smaller event windows are adopted to minimise clustering, clustering cannot be completely nullified due to the protracted and complex nature of the ordinary legislative procedure (Section 2.1). The percentage of clustered events remains high regardless of estimation period length, as shown in Figure 6.2. Further, the clustered events shown in Figure 6.2 are *known* regulatory events which affect the energy sector. Other unobservable events or variables may also affect energy sector valuation. As noted in Section 4.1, despite the decline in market capitalisation as a result of the GFC, a further impact of the GFC was energy demand decreasing by 4.9% in the first quarter of 2009 (IEA, 2009). While this chapter controls for a broad range of macroeconomic variables and regulatory events, such latent variables are difficult to predict and exist regardless of any empirical approach adopted. One positive observation regarding the regulatory changes is that no two events occur within 2 days of each other. This ensures that the narrow event windows surrounding the event will not be contaminated.

TABLE 6.2: SUMMARY OF LEGISLATION STATISTICS

Table 6.2 provides summary statistics of the legislative procedures, including the mean lag between events, median lag, standard deviation, 25th percentile, 75th percentile, minimum and maximum lags. The unit of measurement is trading days.

	Mean Lag	Median Lag	Standard Deviation	25th Percentile	75th Percentile	Min	Max
1st Position	137.7	102.0	139.0	37.0	181.0	2.0	544.0
2nd Position	129.5	95.0	133.7	47.0	149.0	2.0	563.0
Signature Dates	100.0	67.0	108.3	33.5	124.0	4.0	586.0
Publication Dates	97.0	68.5	110.7	35.8	101.5	2.0	597.0
All Events	29.6	15.0	55.0	7.0	28.0	2.0	486.0

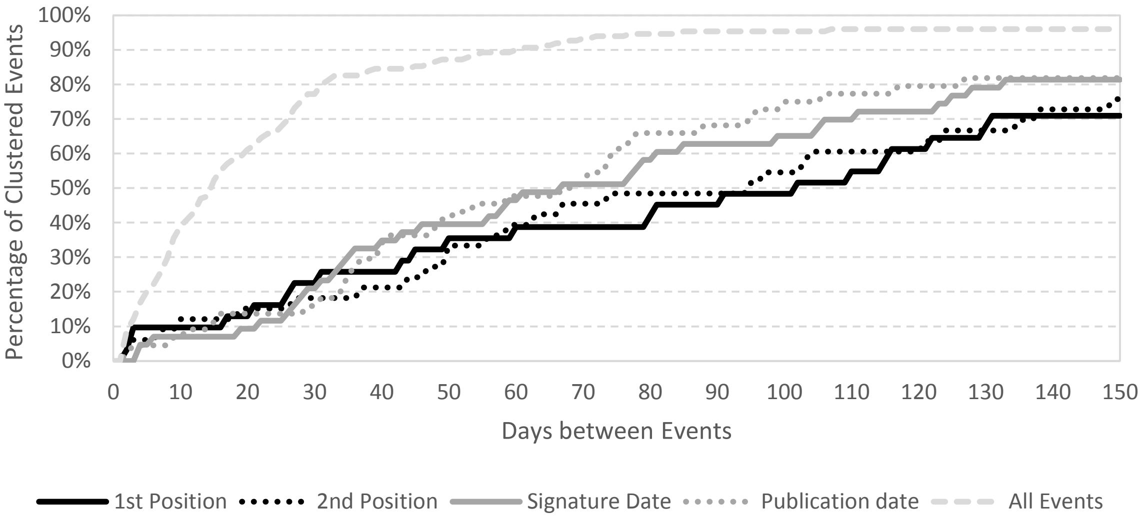


FIGURE 6.2: PERCENTAGE OF CLUSTERED EVENTS BASED ON ESTIMATION PERIOD LENGTH

This figure illustrates the percentage of clustered avents, for the four restructuring streams, across various estimation periods.

Clustered events can mask or reinforce abnormal returns surrounding an event of interest. From an econometric perspective, clustering also affects the calculation of variance of the aggregated sample's cumulative abnormal returns as the covariance across securities are not zero (MacKinlay, 1997). This covariance across securities can lead to inflated t-statistics, also highlighted by Schwert (1981). Reducing the estimation period will reduce clustering, but will also reduce the robustness of the parameters in the normal performance model, which ultimately affects the estimates of abnormal return. The clustering of events and inflated t-statistics can be accommodated by creating a portfolio of abnormal returns portfolios (Schwert, 1981, Bernard, 1987, MacKinlay, 1997). Accordingly, the portfolio approach implemented in Chapters 4 and 5 will control for cross-correlation of abnormal returns. Further, the short event windows surrounding the event can minimise this clustering effect (Klassen and McLaughlin, 1996).

A potential problem of using daily returns is thin trading. Thin trading can have numerous impacts, including: 1) causing statistical tests to be poorly specified, as there are many observations of zero returns and large non-zero returns (Cowan and Sergeant, 1996); 2) distorting variance estimates required for standardized abnormal return tests (Patell, 1976, Campbell and Wesley, 1993); and 3) being more affected by nonsynchronous return periods for the stock and market index (Cowan and Sergeant, 1996). The latter issue results in biased model parameters in an OLS model (Dimson, 1979). Thin trading is typically an issue for small stocks, where Cowan and Sergeant observe 43.9% (4.9 million) zero daily return observations on the 1993 CRSP NASDAQ sample at the firm-level. Thin trading is unlikely to be an issue for this thesis as, across the 88 energy utilities tested, only 0.076% (163 of

213,842 observations) zero daily returns were observed between 1996 and 2013. Further, Section 4.3.2.1 shows that the sector as a whole behaves like big European stocks. To investigate nonsynchronous trading, the mean model parameters in the event study will be compared to those obtained using the local AFFM in Table 5.5.

Further potential criticisms include markets over- or under-estimating the impact of any regulation on financial return (De Bondt and Thaler, 1985, Klassen and McLaughlin, 1996, Jegadeesh and Titman, 2001) or the impact of 'insider information', where a small number of individuals have advanced knowledge regarding the likely outcome of a regulatory change. These confounding variables are also unobservable. The separation of the estimation and the event windows limits any contamination from insider trading (Klassen and McLaughlin, 1996).

6.4 Results

This chapter addresses two overarching research objectives, namely: 1) At what stage of the ordinary legislative procedure do investors incorporate information about regulatory change? 2) How have these regulatory changes impacted the financial returns and valuation of EU energy utilities? The two research objectives are addressed through five hypotheses.

The results section of this chapter is structured as follows. Section 6.4.1 presents the descriptive statistics of the chapter, focusing on the regulatory changes. Section 6.4.2 presents the econometric results of the event study. Specifically, Section 6.3.3.1 presents the results regarding the timing of market reaction surrounding regulatory changes, addressing H_1. Section 6.3.1.2 presents the results regarding the impact of the four distinct restructuring streams, addressing H_2 to H_5.

6.4.1 Descriptive Results

For descriptive and summary statistics regarding the 12 stock portfolios and the risk factors used in the analysis, see Sections 5.4.1.1 and 5.4.1.2, respectively. Table 6.3 presents descriptive statistics regarding regulatory changes. The mean number of trading days between the 1st position and the 2nd position is 58 days, with a standard deviation of 51.2 days. The maximum and minimum ranges show that the time between both political institutions agreeing on a legislative proposal can vary between two days to a little under a year.[68] The unadjusted descriptive statistics regarding the lag between the announcement of the 2nd position and the signature date are biased by a single outlier (532 days). The adjusted

---

[68] As outlined in Section 2.1.5, the first reading at the Parliament and the Council has no time limit. The 90-day time limit only applies to the second reading. Up to 72% of legislative proposals are agreed upon at the first reading (European Parliament et al., 2007).

summary statistics show that the mean lag is much shorter. Typically, there is just over a one-month lag between the 2nd position and the signature date. As shown in Section 2.1.5, in most cases, the agreed upon legislation is only a reasonably finalised text which requires legal-linguistic finalisation. In some cases, the proposal is agreed upon and signed on the same day, indicating that the texts in these circumstances is already finalised. The lag between the signature date and the publication date is typically 22.8 days, well within the expected two-month limit (see Section 2.1.5). The lag between each key stage lends some support to the ability to examine the impact at each stage of the ordinary legislative procedure, related to **H_1**.

TABLE 6.3: DESCRIPTIVE STATISTICS REGARDING REGULATORY CHANGES

Descriptive statistics regarding the four stages of the ordinary legislative procedure

	1st Position to 2nd Position Lag (days)	2nd Position to Signature Lag (days)		Signature to Publication Date Lag (days)
		Unadjusted	**Adjusted**	
Mean	58.0	37.1	25.3	22.8
Median	40.0	18.0	18.0	20.5
Standard Deviation	51.2	78.8	22.8	14.1
25th Percentile	12.0	10.0	10.0	10.5
75th Percentile	91.0	32.0	29.5	31.5
Minimum	2.0	0.0	0.0	1.0
Maximum	236.0	532.0	94.0	65.0

Using the signature date, Figure 6.3 shows the cumulative number of regulatory changes that occur through time, both delineated by the restructuring stream and the aggregate amount. For all regulatory changes, the figure shows a relatively linear relationship through time, with an unusually large amount of legislation being signed in 2003 and 2009. The Internal Energy Market stream is responsible for the increased number of regulatory changes in 2003 and 2009, surrounding the second and third packages of liberalisation. The Renewable Energies and Security of Supply streams contain relatively few publications, which are sporadic and infrequent through time.

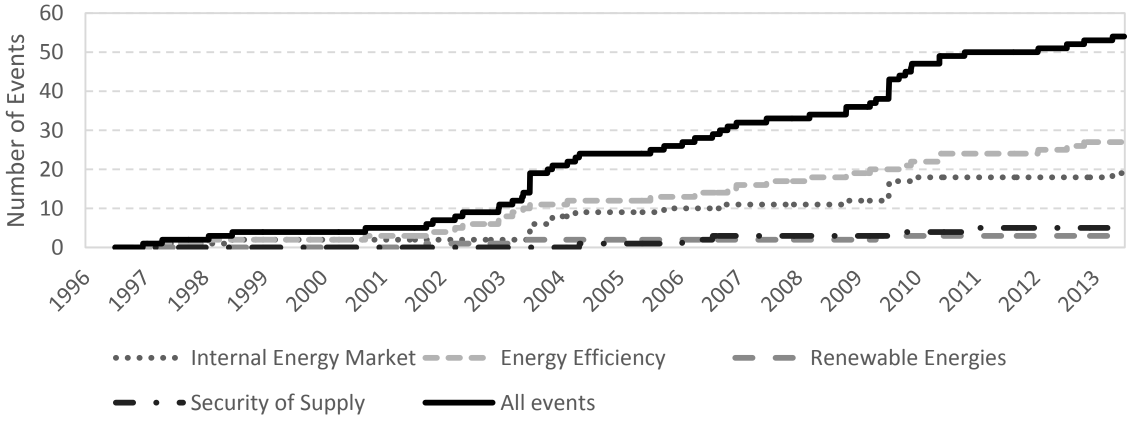


FIGURE 6.3: NUMBER OF REGULATORY EVENTS THROUGH TIME

Figure 6.3 represents the cumulative number of regulatory events between 01 July 1996 and 28 June 2013. The signature date is chosen as it represents the the date at which a legislative proposal is finalised and signed.

6.4.2 Main Results of the Event Study

This section presents the econometric results of the event study approach. The event study will answer the five hypotheses of this chapter. Section 6.4.2.1 answers the first hypothesis regarding the timing of market reaction. Section 6.4.2.2 answers four hypotheses regarding the restructuring streams. The following section presents the results regarding the timing of market reaction.

6.4.2.1 The timing of market reaction

The first stage of the analysis focuses on the timing of market reaction surrounding four key stages of the legislative procedure: the announcement of the 1st position, the announcement of the 2nd position, the signature date and the publication date. The timing of market reaction is important as market inefficiency creates arbitrage opportunities which can negatively impact uninformed market participants and the valuation of firms (Griffin et al., 2015).

First, Beaver's (1968) U_t return variance ratios surrounding the four key stages of the ordinary legislative procedure are presented in Figure 6.4. Plot A of Figure 6.4 shows the peak in return variance is on day -1 preceding the announcement of the 1st position. The magnitude of return variance is 4.46 times greater than the average during the estimation window. The above-normal price activity is congruent with expected changes in equilibrium prices as a result of regulatory changes, where the 1st position possesses informational of value to investors. There are various interpretations for the low return variance prior to the announcement, including: 1) investors postponing trading until more informational content is released (Beaver, 1968), or 2) de-risking prior to an announcement. The return variance ratios, both before and following the announcement, are consistent with Beaver's (1968) empirical results and interpretation.

The announcement of the 2nd position (Plot B) shows a large increase in return variance in both the weeks preceding and the days following the announcement of the 2nd position. This date represents the point at which the 2nd political institution agrees upon the legislative proposal and the document will transition to the signing procedure. Thus, this date represents the effective point at which the proposal will pass into law. The return variance ratio is up to 8.14 times greater surrounding the 2nd position compared to the estimation window. There is little to no market reaction surrounding both the Signature (Plot C) and Publication dates (Plot D), which is consistent with both dates having little to no new informational content and being merely ceremonial. Overall, the results are consistent with market efficiency, with the 1st and 2nd positions containing the majority of the informational content.

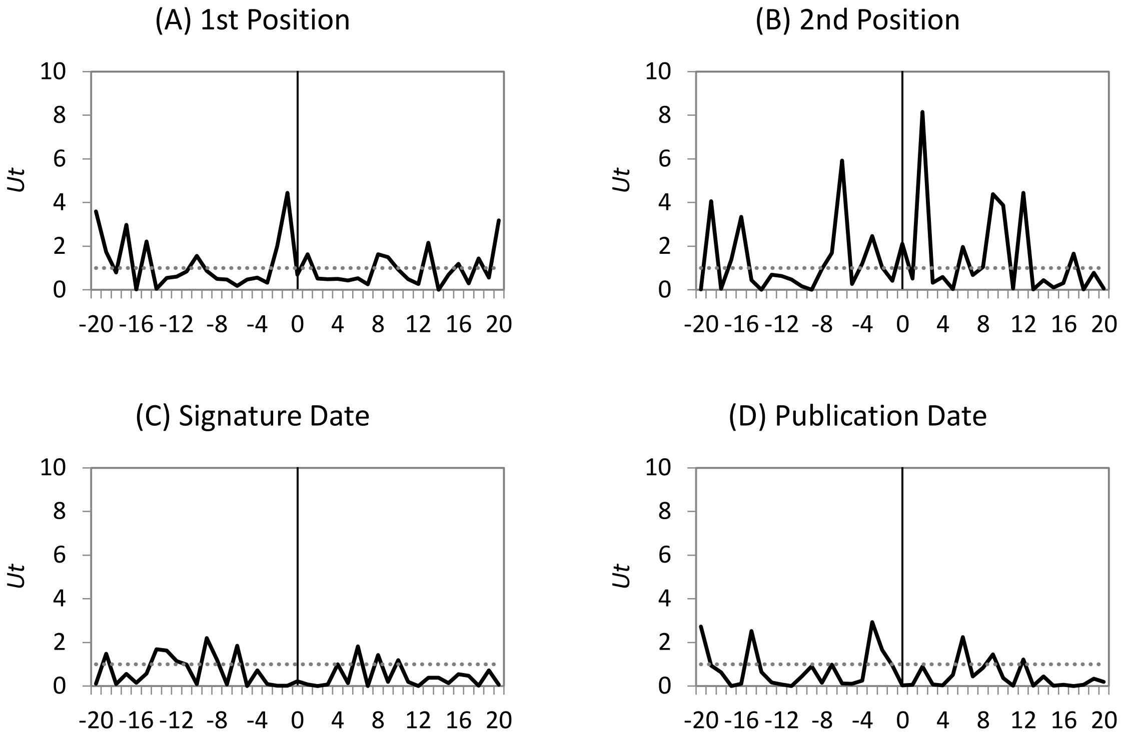


FIGURE 6.4: BEAVER'S PRICE RESIDUAL ANALYSIS SURROUNDING THE FOUR EVENT DATES

This figure presents the measure of U_t for the energy utility sector, as a whole, surrounding the four key stages of the ordinary legislative procedure. The U_t values are plot relative to day zero for the: announcement of the 1st position (Plot A), announcement of the 2nd position (Plot B), signature date (Plot C) and the publication date (Plot D). A measure of $U_t = 1$ is illustrated using a dashed line. A value of U_t above the dashed line indicates greater return variance and is consistent with the incorporation of new information.

To measure direction and significance, Figure 6.5 presents the CAARs for the energy sector as a whole surrounding each of the four stages of the legislative procedure (Plots A to D). Tests of significance across the eight event windows are presented in Table 6.4. Appendix G presents the underlying abnormal returns (ARs), and associated significance surrounding the four stages, through time; Tables G.1 to G.4. The results are consistent with those observed in Figure 6.4. Panel B of Appendix G also presents the mean model parameters, which are similar to those obtained in Table 5.5, further supporting that nonsynchronous trading and thin trading were not econometric issues in the dataset.

The first observation is the abnormal returns of utilities are declining across time. Regarding the 1st position (Figure 6.5., Plot A), there is a significant and negative market reaction in the 10 days preceding the announcement. The $(-10, -1)$ window surrounding the 1st position has CAARs of -0.66% ($p \leq 0.1$), with the majority of this market reaction occurring in the narrow $(-1,1)$ and $(-2,2)$ event windows, with CAARs of -0.41% and -0.48%, respectively, both significant at $p \leq 0.1$. Table G.1 reports that most portfolios experience negative and significant negative ARs on day -1 preceding the announcement of the 1st position – congruent with the Beaver's price residual analysis. Where significant, the negative ARs range between -0.05% and -0.34% on day -1. These results, combined with those presented in Table G.1, show that the market responds narrowly around the announcement. From day -3 to day 0, CAARs decline from -0.38% to -0.80%. This could be due to information leakage from the public readings and consultations or speculation on the likely outcome of a vote. Although the CAARs continue to decline after day 0, Table 6.4 shows that these CAARs are not significantly different from zero. As shown in Figure 2.1, Figure 2.2 and outlined in Section 2.1, the announcement of the 1st position often occurs after lengthy consultations and trilogues. Further, Section 2.1.2 noted that 72% of legislative proposals were agreed upon in the first reading, while 23% were agreed upon in the second reading (European Commission, 2009, European Parliament et al., 2007). The first announcement to accept or amend a piece of legislation is a strong indicator that the legislation is likely to pass into law.

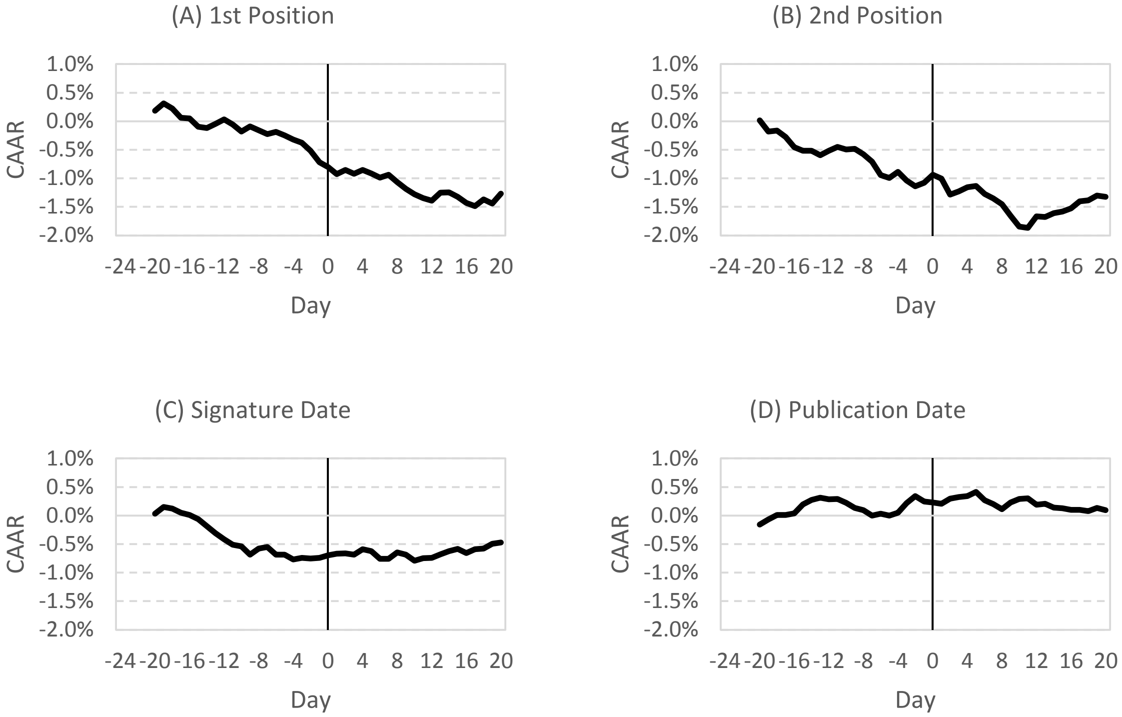


FIGURE 6.5: CAARS OF THE EVENT WINDOWS SURROUNDING THE FOUR EVENT DATES

This figure presents the CAARs for the energy utility sector, as a whole, surrounding the four key stages of the ordinary legislative procedure. The CAARs are plot relative to day zero for the: announcement of the 1st position (Plot A), announcement of the 2nd position (Plot B), signature date (Plot C) and the publication date (Plot D). Tables G.1 to G.4 in Appendix G show the ARs and associated significance tests.

TABLE 6.4: CAARS FOR WINDOWS SURROUNDING EVENT DAYS

This table presents the CAARs for various event windows surrounding the event day for the four key stages of the legislative procedure: announcement of the 1st position, announcement of the 2nd position, signature date and publication date. While Figure 6.4 reports the CAARs day-by-day, this table reports the CAARs over the event window specified. A t-test identifies whether the reported CAAR is statistically different from zero. A ****, ***, * or * denotes significance at 0.1%, 1%, 5% or 10%, respectively.

Event Window	1st Position Announcement		2nd Position Announcement		Signature Date	Publication Date
(-20,20)	-1.27%		-1.32%		-0.47%	0.09%
(-20,-1)	-0.72%		-1.08%	*	-0.74%	0.25%
(-10,-1)	-0.66%	*	-0.62%	**	-0.23%	-0.04%
(0,0)	-0.08%		0.14%	*	0.05%	-0.02%
(-1,1)	-0.41%	*	0.13%		0.08%	-0.14%
(-2,2)	-0.48%	*	-0.24%		0.08%	0.08%
(1,10)	-0.48%		-0.91%		-0.10%	0.06%
(1,20)	-0.47%		-0.39%		0.22%	-0.13%

The CAARs of the 2nd position (Figure 6.5, Plot B) also show statistical significance in the weeks preceding the announcement. Table 6.4 shows negative CAARs occurring in the $(-20,-1)$ and $(-10,-1)$ event windows, with CAARs of -1.08% ($p \leq 0.1$) and -0.62% ($p \leq 0.05$), respectively. Table G.2 shows that significant and negative ARs occur between days -19 and -15. Negative ARs are also observed in the weeks preceding the announcement of the 2nd position; from day -8 to -1. Where significant, negative ARs range from -0.08% to -0.33%. There is a minor positive and significant impact on day 0, with a CAAR of 0.14% $(p \leq 0.1)$, but it suggests only a minor correction to prices at the announcement. This may also be consistent with a stock rebound following an overreaction in the lead up to the announcement or, alternatively, selling stocks prior to the announcement in an effort to de-risk and then re-risking once the full impact of the announcement is known. The significance before the announcement is again likely due to investors closely monitoring the public readings and consultations, outlined in Section 2.1. The significant change in price prior to the announcement suggests that investors anticipate this 2nd position announcement or speculate on the likely outcome of the vote. Rationally, this is expected, as it represents the point at which the two political institutions vote to adopt a reasonably finalised version of the legislative proposal and investors will be aware that a policy is in gestation, as was evident from their reaction to the 1st position. Table G.2 shows that the significant and negative ARs following the announcement, from day 2 onwards, continue to decrease prices and result in the negative CAARs observed. Table 6.4 shows the $(1,10)$ event window following the announcement shows negative CAARs of -0.91%, with marginal significance at $p = 0.1079$. This may represent some lagged reaction, or possible adjustment during the legal-linguistic stage of the legislative procedure.

Regarding the signature date (Figure 6.5, Plot C), the results show no significant impact across all event windows. However, the $(-20,-1)$ event window only marginally misses significance, $p = 0.1083$; beyond this, p-values were all greater than 0.4486 for the remaining event windows. Table G.3 shows some significant and negative ARs between days -20 and -6 for the energy sector as a whole. Table 6.4 shows that there is almost no market reaction surrounding the signature date, with CAARs being almost zero. This is also observed by the stable CAARs in Figure 6.5 and the lack of significant ARs between days -6 and 6 in Table G.3. The interim period between the 2nd position and the signature date represents the point at which the Parliament and the Council issues a press release that an agreement has been reached, the document is finalised and they (ceremonially) sign the document at a monthly meeting. The CAARs in the $(1{,}20)$ event window after the 2nd position and the $(-20, -1)$ event window preceding the signature date may possibly capture the same market reaction. The adjusted descriptive statistics in Table 6.3 show that the events are separated by an average of 25.3 days; therefore, the ± 20 event windows have some minor overlap.

The lack of significant CAARs continues in the event windows surrounding the publication date (Plot D). This suggests that all information has already been incorporated into stock prices before the publication date. The CAARs surrounding the publication date are almost zero, with no statistical significance. Table G.4 shows a similar pattern, with no significant ARs occurring between days -3 and 6.

Addressing $\boldsymbol{H_1}$, Figure 6.5, Table 6.4 and Appendix G show results consistent with market reactions occurring surrounding the early stages of the legislative procedure. In particular, the market reacts to the announcements of the 1st and 2nd position, while the signature and publication dates show no significant market reaction. The results are consistent with finance theory on asset pricing and the impact of regulatory changes (see Sections 3.2.1 and 3.3.1, respectively). In particular, investors appear to anticipate information at the early stages of the legislative procedure and have already incorporated the majority of the information by the announcement of the 2nd position – representing the point at which a piece of legislation has been agreed upon. At this point, there is a high probability that the legislation will pass into law due to the lengthy trilogues which facilitate early agreement (see Section 2.1.3). There is also a small impact occurring in the interim period between the announcement of the 2nd position and the signature date; as noted in Section 2.1.5, some informational content in the legislation can change during the legal-linguistic period. Finally, there is no significant market reaction once information is public. The press release, signature and publication dates have little impact of stock prices as these stages contain no new informational content and are mostly ceremonial.

Referring to the propositions in Section 3.2, measuring the impact on the sector does not allow for within-sector heterogeneity, obscuring important peculiarities regarding market responses. Chapter 5 showed that the energy sector as a whole typically represents big, low-BE/ME energy utilities. To further address ***H₁***, the analysis continues by implementing the event study approach on the 12 energy portfolios, examining the differential timing of market response based on firm characteristics. The timing of market response, surrounding the four key stages of the legislative procedure, is explored for the 12 sector portfolios outlined in Section 5.3.2.1. The purpose is to examine whether the timing of response is sector-wide or depends on firm characteristics. The results for the 12 portfolios are shown in Figure 6.6, across the four key stages of the legislative procedure (Plots A to D). Table 6.5 presents the tests of significance across the eight event windows defined in Section 6.3.1.2. ARs for all 12 portfolios are also presented in Tables G.1 to G.4 in Appendix G. Fundamentally, the results are congruent to those in Table 6.4.

Addressing the 1st position in Table 6.5 (Panel A), while there is some negative reaction in the weeks preceding the announcement, the majority of impact primarily occur in the narrow event windows surrounding the announcement, event windows $(-1,1)$ and $(-2,2)$. Of the 12 portfolios tested, six portfolios have significant and negative impacts within these narrow event windows. Across all event windows, the market reaction for big utilities is similar to that of the energy sector as a whole – unsurprising as Section 5.3.2.1 shows that big energy utilities typically represent 93.6% of sector valuation. Note, the mid-BE/ME portfolios also experience large negative impacts. Table 5.2 showed that the mid-BE/ME portfolio typically has large market capitalisation and large book value of equity, potentially indicating asset stranding as a result of regulatory changes. Small and high-BE/ME portfolios experience some negative market reactions around the 1st position; these portfolios are expected to be relatively riskier investments. All momentum portfolios also show some significant impact surrounding the 1st position, suggesting the impact that persistent winners and losers are also affected by regulatory changes. Importantly, the natural gas sector shows the largest negative reaction of all utility portfolios, with CAARs of -4.71% in the $(-20,20)$ event window. This is consistent with the negative impact of regulatory changes reported by The Economist (2013a, b, c) (see Section 1.2). The results show the market reaction surrounding the announcement of the 1st position is generally negative and large, suggesting that factors beyond parameters of the AFFM are decreasing the underlying value of most utilities.

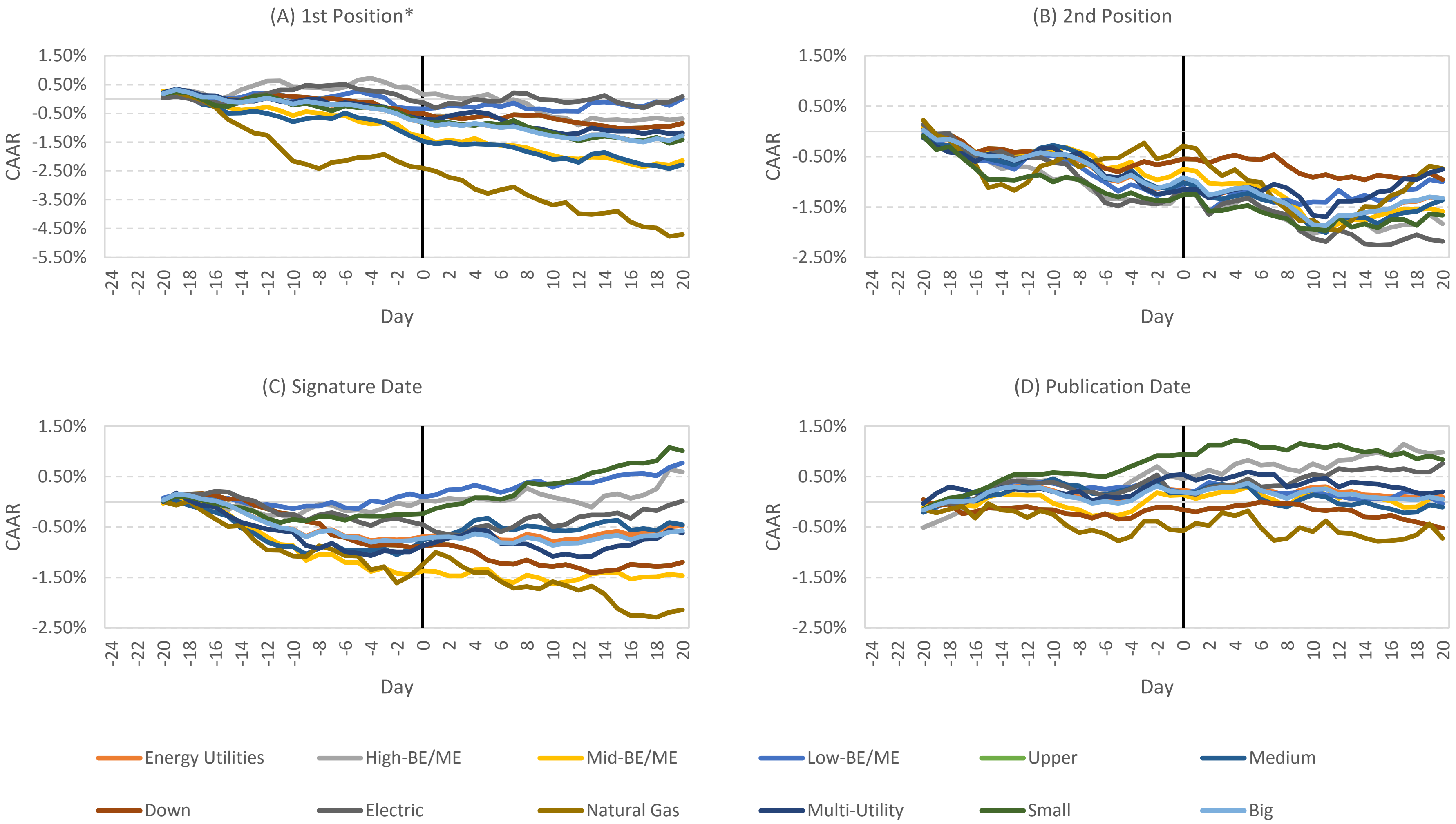


Figure 6.6 CAARs for the Four Event Dates, Across 12 Portfolios

This figure presents the CAARs for the 12 energy sector portfolios surrounding the four key stages of the ordinary legislative procedure. This figure extends Figure 6.4, showing the heterogeneous impact of various energy portfolios. *Scale is greater than the other three stages

TABLE 6.5: CAARS SURROUNDING REGULATORY EVENTS BY PORTFOLIOS

This table reports the CAARs of various event windows surrounding the 1st position, 2nd position, signature date and publication dates. The results are presented in Panels A, B, C and D, respectively. The CAARs are estimated using the local AAFM outlined in Equation (6.1). A ****, ***, ** or * denotes significance at 0.1%, 1%, 5% or 10%, respectively.

Panel A: CAARs Surrounding the 1st Position Event Windows and Significance Tests

	(-20,20)	(-20,-1)	(-10,-1)	(0,0)	(-1,1)	(-2,2)	(1,10)	(1,20)
Energy Utilities	-1.27%	-0.72%	-0.66% *	-0.08%	-0.41% *	-0.48% *	-0.48%	-0.47%
High-BE/ME	-0.68%	0.39%	-0.24%	-0.22%	-0.24%	-0.53% **	-0.79% *	-0.85%
Mid-BE/ME	-2.14% **	-1.21% **	-0.80% *	-0.09%	-0.64% **	-0.60% *	-0.65% *	-0.84%
Low-BE/ME	0.01%	-0.33%	-0.48%	-0.01%	-0.03%	-0.28%	-0.08%	0.35%
Upper	-0.85%	-0.49%	-0.62% **	-0.01%	-0.28% *	-0.32%	-0.17%	-0.34%
Medium	-2.28% **	-1.28% **	-0.66%	-0.19%	-0.50% **	-0.70% **	-0.63%	-0.81%
Down	-0.85%	-0.49%	-0.62% **	-0.01%	-0.28% *	-0.32%	-0.17%	-0.34%
Electric	0.09%	-0.05%	-0.37%	-0.06%	-0.46%	-0.40%	0.09%	0.21%
Natural Gas	-4.71% *	-2.34% *	-0.63%	-0.06%	-0.36%	-0.80%	-1.28% *	-2.31%
Multi-Utility	-1.18%	-0.61%	-0.53%	-0.09%	-0.21%	-0.32%	-0.44%	-0.47%
Small	-1.41%	-0.64%	-0.62%	-0.20%	-0.35%	-0.52% **	-0.35%	-0.57%
Big	-1.27%	-0.72%	-0.66% *	-0.07%	-0.42% *	-0.48% *	-0.49%	-0.47%

Panel B: CAARs Surrounding the 2nd Position Event Windows and Significance Tests

	(-20,20)	(-20,-1)	(-10,-1)	(0,0)	(-1,1)	(-2,2)	(1,10)	(1,20)
Energy Utilities	-1.32%	-1.08% **	-0.62% **	0.14% *	0.13%	-0.24%	-0.91%	-0.39%
High-BE/ME	-1.83%	-1.43% **	-0.64% *	0.25%	0.16%	-0.24%	-0.84%	-0.64%
Mid-BE/ME	-1.59%	-0.90%	-0.56%	0.15%	0.18%	-0.16%	-1.17% *	-0.84%
Low-BE/ME	-1.00%	-1.19% **	-0.72% *	0.08%	0.02%	-0.46%	-0.29%	0.11%
Upper	-0.96%	-0.62% *	-0.19%	0.07%	0.11%	-0.03%	-0.36%	-0.41%
Medium	-1.36%	-1.14% *	-0.81% **	0.12%	0.04%	-0.31%	-0.90%	-0.34%
Down	-0.96%	-0.62% *	-0.19%	0.07%	0.11%	-0.03%	-0.36%	-0.41%
Electric	-2.18% *	-1.35% **	-0.84% **	0.21% *	0.18%	-0.24%	-0.99%	-1.04%
Natural Gas	-0.74%	-0.47%	0.22%	0.18%	0.21%	-0.44%	-1.47%	-0.45%
Multi-Utility	-0.75%	-1.21% **	-0.87% **	0.05%	0.09%	-0.20%	-0.50%	0.41%
Small	-1.66% *	-1.37% **	-0.50%	0.11%	0.13%	-0.26%	-0.68%	-0.40%
Big	-1.33%	-1.06% **	-0.64% **	0.14% *	0.14%	-0.24%	-0.93%	-0.41%

Table 6.5 (continued)

	Panel C: CAARs Surrounding the Signature Date Event Windows and Significance Tests							
	(-20,20)	**(-20,-1)**	**(-10,-1)**	**(0,0)**	**(-1,1)**	**(-2,2)**	**(1,10)**	**(1,20)**
Energy Utilities	-0.47%	-0.74%	-0.23%	0.05%	0.08%	0.08%	-0.10%	0.22%
High-BE/ME	0.60%	-0.08%	0.17%	0.11%	0.03%	0.19%	0.06%	0.57%
Mid-BE/ME	-1.47%	-1.45% **	-0.60%	0.08%	0.03%	-0.16%	-0.26%	-0.10%
Low-BE/ME	0.77%	0.16%	0.25%	-0.06%	0.05%	0.25%	0.20%	0.68%
Upper	-1.20% *	-0.90% *	-0.68% **	0.02%	0.01%	0.00%	-0.40% *	-0.32%
Medium	-0.45%	-0.93% *	-0.05%	0.17%	0.35% **	0.28%	0.19%	0.31%
Down	-1.20% *	-0.90% *	-0.68% **	0.02%	0.01%	0.00%	-0.40% *	-0.32%
Electric	0.02%	-0.40%	-0.13%	-0.06%	-0.27%	-0.29%	-0.05%	0.47%
Natural Gas	-2.14%	-1.47%	-0.51%	0.23%	0.61% *	0.19%	-0.34%	-0.90%
Multi-Utility	-0.62%	-0.99% *	-0.42%	0.12%	0.19%	0.25%	-0.21%	0.25%
Small	1.02%	-0.25%	0.17%	0.01%	0.12%	0.21%	0.59% *	1.25% *
Big	-0.57%	-0.77%	-0.26%	0.05%	0.08%	0.07%	-0.14%	0.15%

	Panel D: CAARs Surrounding the Publication Date Event Windows and Significance Tests							
	(-20,20)	**(-20,-1)**	**(-10,-1)**	**(0,0)**	**(-1,1)**	**(-2,2)**	**(1,10)**	**(1,20)**
Energy Utilities	0.09%	0.25%	-0.04%	-0.02%	-0.14%	0.08%	0.06%	-0.13%
High-BE/ME	0.99%	0.51%	0.09%	-0.05%	-0.18%	0.08%	0.30%	0.53%
Mid-BE/ME	0.05%	0.13%	0.00%	0.01%	-0.12%	0.14%	0.03%	-0.09%
Low-BE/ME	-0.04%	0.24%	-0.16%	-0.05%	-0.22%	0.01%	0.05%	-0.22%
Upper	-0.52%	-0.11%	0.04%	-0.05%	-0.09%	0.05%	0.00%	-0.36%
Medium	-0.10%	0.17%	-0.19%	0.01%	-0.19%	-0.06%	-0.05%	-0.29%
Down	-0.52%	-0.11%	0.04%	-0.05%	-0.09%	0.05%	0.00%	-0.36%
Electric	0.76%	0.21%	-0.16%	-0.02%	-0.38% **	-0.11%	0.35%	0.57%
Natural Gas	-0.72%	-0.55%	-0.37%	-0.03%	-0.04%	-0.08%	-0.01%	-0.14%
Multi-Utility	0.20%	0.52%	0.25%	0.02%	0.01%	0.22%	-0.11%	-0.34%
Small	0.84%	0.92% *	0.38%	0.02%	0.02%	0.32% *	0.17%	-0.10%
Big	0.05%	0.21%	-0.07%	-0.02%	-0.15%	0.06%	0.06%	-0.14%

For the signature date in Table 6.5 (Panel C), the number and magnitude of significant CAARs are much lower compared with the announcements of the 1st and 2nd positions. Momentum portfolios show some negative impact, all approximately 0.90%, in the weeks preceding the signature date. For the upper and down momentum portfolios, the impact continues in the (1,10) event window. Multi-utilities and mid-BE/ME utilities also have negative CAARs in the $(-20,-1)$ event window preceding the signature date. As noted previously, the weeks preceding the signature date may also capture some lagged impact after the 2nd position. Natural gas and medium momentum utilities experience some minor correction, of 0.61% $(p \leq 0.1)$ and 0.35% $(p \leq 0.05)$, respectively. The most important feature of the signature date is that small utilities experience a large and positive shift following the signature date, with CAARs up to 1.25% $(p \leq 0.1)$. The positive CAARs almost completely correct the negative CAARs experienced preceding the 2nd position. This may be evidence of hard-to-process information, where the full impact of the regulatory change is difficult to judge for small utilities, which are typically associated with less information compared with larger utilities (Kumar, 2009). This is consistent with the soft information in Demers and Vega (2008) and Engelberg (2008), where the qualitative nature of the regulatory change is difficult to process and results in lagged responses and larger investment mistakes (Kumar, 2009) (see Section 6.2.1).

Finally, the publication date in Table 6.5 (Panel D) results in very few statistically significant CAARs. Rationally, the majority of the informational context regarding the regulatory change is expected to already be impounded into stock prices. Results show that electric utilities experience a negative market reaction of -0.38% $(p \leq 0.05)$ in the $(-1,1)$ event window surrounding the publication date. In contrast, small utilities experience large and positive CAARs of 0.92 $(p \leq 0.1)$ for the $(-20,-1)$ event window, and an additional positive impact of 0.32% $(p \leq 0.1)$ in the narrow $(-2,2)$ event window – further evidence of the delayed positive impact for small utilities. The results are consistent with the expected impact of regulatory changes, where liberalisation objectives benefit small utilities (see Section 2.2.1). Although the abnormal returns of small utilities initially decline in tandem with other portfolios, it may be evidence of overreaction. Similar to Oberndorfer's (2009a) interpretation for oil, hard-to-value small utilities may be benchmarked against the rest of the sector, where price developments of the sector are assumed to affect small utilities. Market prices are corrected when the full extent of the regulatory changes for small utilities is realised.

Overall, the results are congruent with those for the sector as a whole, but provide greater detail regarding the within-sector heterogeneity regarding market responses. Overall, the results show support for ***H_1***: the market reaction primarily occurs surrounding the announcement of the 1st and 2nd positions. Again, this is congruent with market efficiency and rational investors, who incorporate information as soon as it is anticipated (see Sections 3.2 and 3.3.1). There is some evidence of lagged response for small utilities. The implications of these results are that equity markets are efficient at pricing regulatory change into the value of energy utilities with the one exception being the smaller utilities which, like most small companies, are subject to high levels of information asymmetry and uncertainty This result is unsurprising for finance and energy economic academics, but is a novel and important policy contribution regarding the design of the EU ordinary legislative procedure and information diffusion through a protracted legislative procedure.

From a policy context, the results make a contribution by identifying the timing at which the market reacts to information regarding regulatory changes in the energy sector. That is, if a researcher assumes markets will anticipate a regulatory change following the signing, or publication, of a legislative act, then all statistical inferences will be misleading and subject to Type II errors – a *false negative*. As shown above, there is little reaction after the document is signed; therefore, one would incorrectly fail to reject the null of no impact for the alternative of a significant market reaction. In fact, the models also fail to reject the null assuming the market reaction following the announcement of the 2nd position. The market reaction surrounding the announcements of the 1st and 2nd positions shows that information is diffusing into the market prior to announcement or investors are speculating on the likely outcome of the votes. Further, if one were to assume the impact occurs only in the narrow window surrounding event day zero, statistical inference would mostly miss the negative market reactions evolving in the weeks prior to the event date. The smaller impacts at the signature date may be evidence of a lagged response. Lagged responses are also reported by Griffin et al. (2015), who find significant (but smaller) market reactions up to a two-week lag following some events.

The price discovery process is consistent with the differential impact expected from the informational content of the regulatory changes; see Section 2.2.1. The differential impact of the portfolios can be summarised as follows: regulatory changes negatively impact the energy utility sector as a whole, but transfer market power away from big utilities, countering market dominance and predatory behaviour. Natural gas utilities are disproportionately affected by the regulatory changes, as they are typically affected by legislation which aims to reduce reliance on hydrocarbon fuel sources. As expected, the underlying price of small utilities increases as a result of opportunities to take market share. Further, Section 2.2.1 highlights that some small utilities were exempt from the regulatory changes.

With a comprehensive analysis of the timing of market reaction surrounding key stages of the regulatory process, the chapter can continue with the second-stage of the analysis by examining the impact of each of the restructuring streams: Internal Energy Market, Energy Efficiency, Renewable Energies and Security of Supply.

6.4.2.2 The market's response to the four regulatory streams

The second stage of the analysis addresses $\boldsymbol{H_2}$ through to $\boldsymbol{H_5}$, namely: the impact of the Internal Energy Market, Energy Efficiency, Renewable Energies and Security of Supply streams. The structure of this section is as follows. First, Figure 6.7 (Plots A to D) and Table 6.6 present the CAARs of the energy sector as a whole surrounding each of the four stages of the legislative procedure. The CAARs are delineated by restructuring the streams to illustrate each steam's unique impact at each key stage of the procedure. Second, the section continues by examining the within-sector heterogeneity across the 12 portfolios. The oversize tables concerning the eight CAAR significance tests, for all 12 portfolios and across the four restructuring streams, are reported in Appendix H, Tables H.1 to H.4. The following paragraphs address the overall impacts of each restructuring stream on the energy sector as a whole.

Table 6.6 shows that each restructuring stream produces distinct abnormal returns surrounding key stages of the legislative procedure. The Internal Energy Market produces negative CAARs in some of the event windows tested. The majority of the impact occurs in both the weeks preceding and the narrow event windows surrounding the announcement of the 1st position. There is no significant impact for the Internal Energy Market stream at the sector-level beyond the 2nd position, suggesting that investors efficiently incorporate the cash flow implications of the stream. The majority of the impact for the Energy Efficiency stream occurs in the weeks preceding the 2nd position, with no significant impact in any window at the sector level. In contrast to the assertions by the press (see Section 1.2), the Renewable Energies stream has no significant impact at the sector-level. The Security of Supply stream has a significant impact surrounding the announcement of the 1st position and delayed impacts occurring around the signature and publication dates; possibly evidence of hard-to-process information as the stream affects oil prices rather than utilities directly.

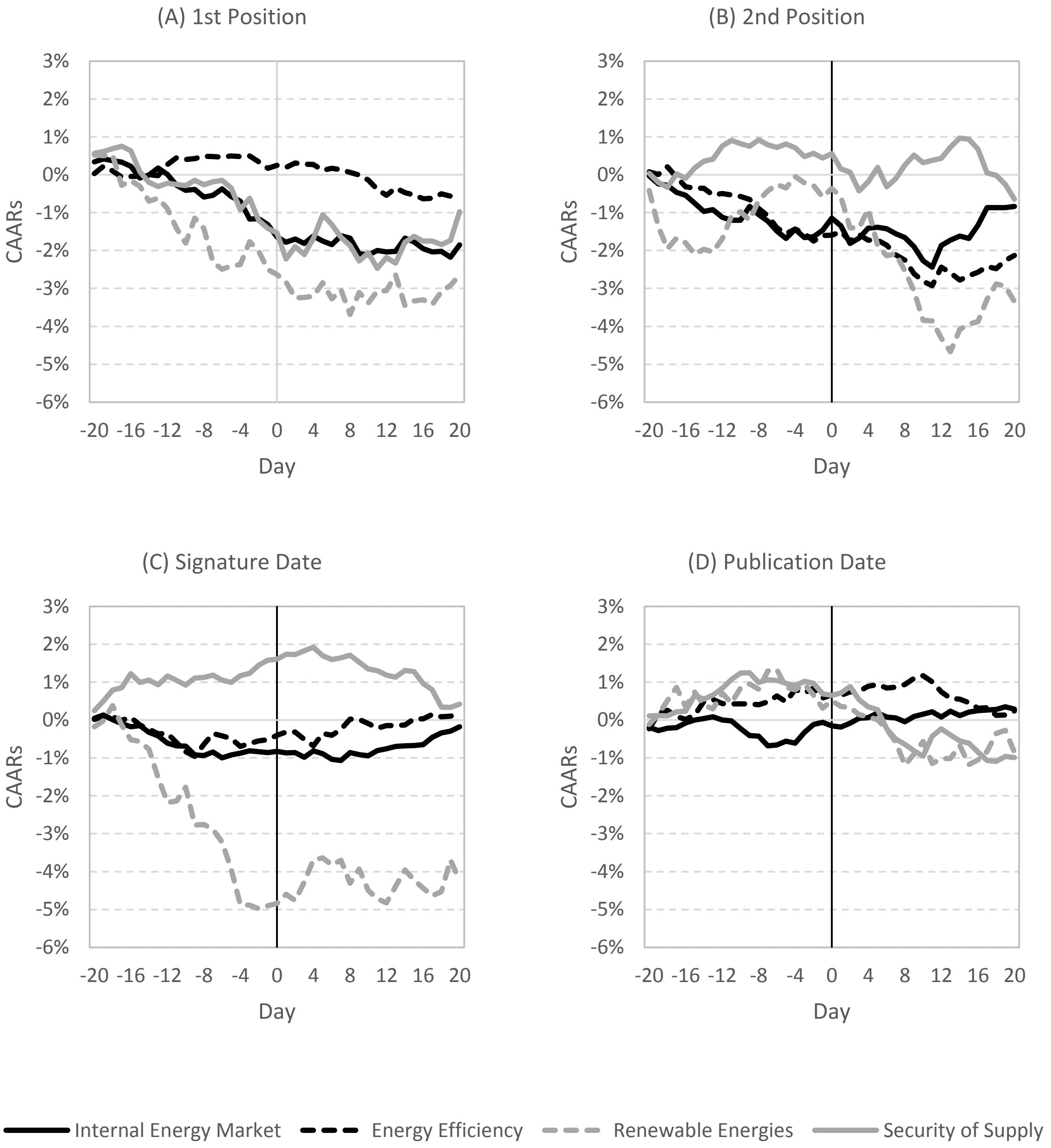


FIGURE 6.7: CAARS FOR THE FOUR RESTRUCTURING STREAMS

Delineating the CAARs into the four distinct restructuring streams, this figure presents the CAARs for the energy utility sector surrounding the four key stages of the ordinary legislative procedure. The CAARs are plot relative to day zero for the announcement of the 1st position (Plot A), announcement of the 2nd position (Plot B), signature date (Plot C) and the publication date (Plot D). Tables G.1 to G.4 in Appendix G show the ARs and associated significance tests.

TABLE 6.6: CAARS SIGNIFICANCE TESTS FOR THE FOUR RESTRUCTURING STREAMS

Delineated by restructuring stream, this table presents the CAARs for various event windows surrounding the event day for the four key stages of the legislative procedure: announcement of the 1st position, announcement of the 2nd position, signature date and publication date. While Figure 6.6 reports the CAARs day-by-day, this table reports the CAARs over the event window specified. A t-test identifies whether the reported CAAR is statistically different from zero. A ****, ***, * or * denotes significance at 0.1%, 1%, 5% or 10%, respectively.

		Panel C: CAARs Surrounding the Signature Date Event Windows and Significance Tests							
Key Stage	**Stream**	**(-20,20)**	**(-20,-1)**	**(-10,-1)**	**(0,0)**	**(-1,1)**	**(-2,2)**	**(1,10)**	**(1,20)**
1st Position	**Internal Energy Market**	-1.85%	-1.32% *	-1.04% **	-0.32% **	-0.62% **	-0.53%	-0.47%	-0.21%
	Energy Efficiency	-0.52%	0.18%	-0.28%	0.08%	-0.15%	-0.19%	-0.39%	-0.77%
	Renewable Energies	-2.65%	-2.50%	-1.08%	-0.13%	-0.82%	-1.49%	-0.75%	-0.01%
	Security of Supply	-0.97%	-1.41%	-1.16%	-0.12%	-1.02%	-1.28% **	-0.52%	0.56%
2nd Position	**Internal Energy Market**	-0.83%	-1.46%	-0.27%	0.32% **	0.28%	-0.15%	-1.12%	0.31%
	Energy Efficiency	-2.13%	-1.60% **	-1.07% **	0.01%	0.25%	-0.19%	-1.22%	-0.54%
	Renewable Energies	-3.35%	-0.59%	0.51%	0.22%	-0.30%	-1.19%	-3.48%	-2.98%
	Security of Supply	-0.64%	0.44%	-0.46%	0.11%	-0.41% *	-0.42%	-0.24%	-1.20%
Signature Date	**Internal Energy Market**	0.16%	-0.51%	0.08%	0.11%	0.23%	0.30%	0.31%	0.56%
	Energy Efficiency	-0.18%	-0.86%	-0.18%	0.03%	-0.03%	-0.05%	-0.12%	0.65%
	Renewable Energies	-4.23%	-4.90%	-2.77%	0.07%	0.38%	0.13%	0.34%	0.60%
	Security of Supply	0.42%	1.59% *	0.54%	0.02%	0.29%	0.50%	-0.26%	-1.19%
Publication Date	**Internal Energy Market**	0.24%	0.58%	0.15%	0.09%	-0.19%	0.04%	0.50%	-0.43%
	Energy Efficiency	0.29%	-0.06%	-0.04%	-0.10%	-0.07%	0.24%	0.31%	0.45%
	Renewable Energies	-0.85%	0.31%	-0.14%	0.20%	-0.30%	-0.61%	-1.08%	-1.37%
	Security of Supply	-0.99%	0.69%	-0.38%	-0.04%	-0.26%	-0.14%	-1.60% **	-1.64% **

The significant abnormal returns previously reported in Figure 6.5 and Table 6.4 are clearly driven by the Internal Energy Market and Energy Efficiency streams. In particular, the Internal Energy Market influences the CAARs surrounding the 1st position, while the Energy Efficiency Stream influences the CAARs surrounding the 2nd position. Despite the large CAARs observed in the Renewable Energies stream, the significance tests show that the impact is not significantly different from zero for the energy sector as a whole. The analysis below will show that this is due to the impact of the Renewable Energies stream being concentrated on the natural gas industry, and does not reflect a sector-wide impact. The same is true for the Security of Supply stream, with very few market reactions across all portfolios.

As shown above, examining the abnormal returns at the sector-level obscures much of the impact of regulatory changes. Many of the regulations in Section 2.2 were designed to target specific energy utilities. As noted in Section 4.2.2, the annexes of some legislation identified the energy utilities expected to be impacted. Accordingly, there is likely to be within sector heterogeneity. The following paragraphs examine the impact of the regulatory changes on 12 portfolios of energy utilities (see Section 5.3.2.1), providing much needed insight into the heterogeneous return profiles of various types European energy utilities. The following paragraphs address $\boldsymbol{H_2}$ to $\boldsymbol{H_5}$.

The first results relate to the Internal Energy Market stream. The Internal Energy Market stream represents sector liberalisation and induced competition objectives (see Section 2.2.1). As noted before, the stream has three overarching objectives: 1) to open national borders, allowing access to previously isolated markets; 2) to legally unbundle vertically integrated utilities, both operationally and in terms of ownership; and 3) to induce competition into the energy sector, addressing market dominance issues. Overall, the stream is expected to have major impacts on future cash flows, particularly for large utilities which lose access to transmission networks and are forced to compete for grid access. As a result, big utilities have an increased risk of asset stranding due to large baseload capacities being underutilised and the inability to scale back operations. The stream is expected to be the most anticipated stream since it results in large changes in the regulatory and operating environment of the energy sector.

For the Internal Energy Market stream, the results in Table H.1 of Appendix H show large and significant negative market reactions in both the weeks preceding and narrow event windows surrounding the announcement of the 1st position (Panel A). In the $(-20,-1)$ and $(-10,-1)$ event windows, CAARs for the sector are -1.32% $(p \leq 0.1)$ and -1.04% $(p \leq$

0.05), respectively. These significant and negative CAARs are primarily the result of negative CAARs observed in the big, medium momentum, and mid-BE/ME[69] utility portfolios. The market reaction for the big utilities begins in the week preceding the 1st position as the impact is expected to affect utilities with larger market capitalisations. In contrast, small utilities have insignificant CAARs in the weeks preceding the announcement and only experience significant and negative CAARs in the narrow event window surrounding the 1st position. Further, the overall impact is lower than big utilities. Similarly, there are negative impacts in the electric and multi-utility industries. The electricity industry is expected to be negatively impacted by induced competition (see Section 3.3.2). Although the natural gas utility portfolio experiences negative CAARs of -6.26% in event window $(-20,20)$, all event windows are insignificant. The lack of significance suggests the CAARs are not abnormal relative to past returns and may be evidence of high volatility in the series. This is congruent with Table 5.2, which shows that the natural gas portfolio has the highest standard deviation relative to other energy portfolios.

Addressing $\boldsymbol{H_2}$ for the Internal Energy Market stream (Table H.1), the majority of the impact occurs surrounding the 1st position (Panel A), with little to no impact surrounding the 2nd position (Panel B), signature date and publication date (Panels C and D, respectively). From a policy perspective, the results are expected. The Internal Energy Market legislative acts are the result of lengthy discussions with the industry, academics and policy makers (see an example in footnote 15, Section 6.4.2.2). Further and as discussed in Section 2.1.1, in March 2015 academics and the director of the internal energy market initiated informal discussions regarding a possible fourth package for the Internal Energy Market, despite no legislative proposal existing to date and it being unlikely to be tabled for some time yet; potentially years away (see FSR Energy, 2015). The discussion outlines potential directions for the 4th package of liberalisation, including the types of utilities which are likely to be affected. When it does come, the announcement of the 1st position will send a strong signal to the market that the legislation is near finalisation and political institutions show positive sentiment towards accepting the proposal. As mentioned in Section 2.1.3, informal trilogues facilitate an early agreement of the proposal, while Section 2.1.2 showed that 72% of all legislative acts are accepted in the first reading.

The Energy Efficiency stream is designed to reduce overall energy consumption in the EU by increasing the efficiency of energy-intensive end-user appliances and reducing energy

---

[69] As shown in Table 5.2, for the European energy utility sector, the mid-BE/ME portfolios represent the largest energy utilities as measured by market capitalisation and book value of equity.

demands from buildings (see Section 2.2.2). Accordingly, energy demand is estimated to decline between 10% to 20% (Delarue et al., 2011). Unlike the Internal Energy Market stream the impact is expected to negatively impact all portfolios as the legislation is designed to decrease energy consumption within the EU.

The results of the Energy Efficiency stream show sparse significance surrounding the 1st position (see Panel A of Table H.2, Appendix H). Typically, small, high-BE/ME and natural gas utilities show some negative CAARs across event windows. The market reaction occurs in the weeks following the announcement of the 2nd position and in the narrow event windows surrounding the announcement date (See Panel B of Table H.2). Similar to the results in Section 6.4.2.1, there is a large impact in the weeks preceding the announcement of the 2nd position. Specifically, the $(-20, -1)$ and $(-10, -1)$ event windows. The impact is observed cross-sectionally across the energy sector, where most portfolios experience significant and negative CAARs, up to -2.44% preceding the 2nd announcement, some significant at $p \leq 0.01$. In particular, small, high-BE/ME, and electric utilities are disproportionately affected by the Energy Efficiency stream. The results show that investors anticipate the negative impact prior to the 2nd vote, subsiding thereafter. The negative impact is large enough to be detected within the energy sector as a whole, and are generally consistent with the results shown in Table 6.5. Surrounding the signature date, there is some price correction for the low-BE/ME and small utility portfolios. There is also some minor price correction for the high-BE/ME and electric utility portfolios following the publication date.

Addressing $\boldsymbol{H_3}$ for environmental objectives, as measured by the Energy Efficiency stream, the results show a cross-sectional market reaction to the stream which is mostly negative and occurs in the event window surrounding the 2nd position. Further, the overall impact of regulatory changes observed in Figure 6.5 and Figure 6.6 is mostly the result of the Energy Efficiency stream. This is hardly surprising, as the stream represents over half of all legislation tested, 27 in total (see Table 2.1). When examining the Energy Efficiency Stream in isolation, the majority of the reaction occurs at an early stage of the legislative procedure, preceding the 2nd position. The reason is evident after reviewing the legislative acts. Whereas the Internal Energy Market legislation requires substantial negotiations among political institutions and lengthy legal-linguistic finalisation, including definitions of which utilities may be impacted by the legislation, the content of the Energy Efficiency legislation is fundamentally different. From the onset, the legislative act identifies an energy-related issue regarding an appliance or property, and therefore results in a potentially narrow, well-defined impact which is easier to process for investors. Further, the legislation reduces energy demand from the user end, which affects all energy utilities simultaneously. As stated in the hypothesis development (Section 6.2.1), the numerical targets for overall energy consumption reductions, are akin to the hard information in Demers and Vega (2008) and Engelberg (2008). The quantitative nature of the legislation means investors are less prone to the investment mistakes suggested by Kumar (2009).

The Renewable Energies stream also addresses environmental objectives through increased use of renewable energy sources and the electrification of the transport sector (see Section 2.2.3). Overall, the Renewable Energies stream is expected to have a negative impact on the natural gas sector, which potentially loses revenue through the electrification of the transport sector – at least 10% of the transport sector must be electrified by 2020.[30]

The results in Table H.3 show almost no significant impact across the 12 portfolios surrounding the announcement of the 1st position (Panel A). The only portfolio affected is natural gas utilities, which experiences negative CAARs of -6.25% ($p \leq 0.1$) in the $(1{,}10)$ event window. The majority of this impact occurs in the narrow $(-2{,}2)$ event window, where CAARs are -5.36% ($p \leq 0.05$). The market reacts to the potential loss of revenue to natural gas utilities. There is no significant impact regarding the remaining 11 portfolios surrounding the 1st position. The $(-20, -1)$ event window prior to the 2nd position shows a significant and negative impact for electric utilities, with CAARs of -2.11% ($p \leq 0.05$), and a small correction on the announcement date of 0.44% ($p \leq 0.1$). Surrounding the signature and publication dates, natural gas utilities experience large price corrections. This may represent the market correcting prices once the full extent of the legislative act is defined in the legal-linguistic stage. Multi-utilities experience positive impacts surrounding the signature date, with CAARs up to 1.72% ($p \leq 0.05$). As discussed in the descriptive results of Chapter 5 (Section 5.4.1.1), multi-utilities have economy of scope, where diverse business operations are less likely to be exposed to the negative regulatory and operational risks of single utilities. Multi-utilities can switch business operations between the electric and natural gas industries. Low-BE/ME utilities also show some positive significance surrounding the publication date, with CAARs of 1.69% ($p \leq 0.05$). As noted in Section 5.4.1 and Table 5.2, this portfolio typically represents relatively small companies which trade above their BE – these growth utilities are the most likely group which can adapt to the regulatory changes and scale up operations rapidly. Overall, the results are congruent with the propositions outlined in this chapter and Section 2.2.3: firms which are able to adapt experience positive market reactions, while natural gas firms experience a negative market reaction.

Addressing $\boldsymbol{H_4}$, the results show some large abnormal returns in the natural gas industry surrounding the Renewable Energies legislation. Most reactions are negative and the magnitude of CAARs are among the largest across all four restructuring streams. Contrary to claims, such as The Economist's (2013b), the Renewable Energy legislation has had little impact on the sector, but in fact has specific impacts based on firm characteristics. To their credit, the article in The Economist (2013b) mostly considers the impact of renewables on a selection of large, combination-fuel generators,[70] which also have large stakes in the natural gas industry or use carbon-intensive fuels such as coal. The results of this chapter show the impact of renewable energies is isolated to particular portfolios which are at risk of having stranded assets as a result of increased penetration of renewable energies. Some large utilities have acknowledged the declining role of hydrocarbons in energy generation. For example, Drax has begun making considerable efforts to move away from coal-based generation to a predominantly biomass-fuelled generation (Drax Group plc, 2015).

The Security of Supply restructuring stream is expected to have a positive impact on the most European equities, but a negative impact on energy utilities. The restructuring stream's objectives include ensuring the EU maintains a minimum supply of oil stocks to diminish the harmful effects of disruption to the energy supply, and to ensure that adequate stock is available to enable energy utilities to fuel-switch during fuel crises (see Section 2.2.4). Naturally, industries where oil represents a major output, or the output is benchmarked against oil prices, will suffer a decline in value as a result of decreasing revenue and future cash flows.

As noted in Table 6.1, the 1st position of the Security of Supply stream should be tempered with caution. One of the five Security of Supply legislation shares a 1st position announcement date with the third packages of liberalisation. This impact will be addressed in Section 6.4.3.1. The remaining three key stages are unaffected.

The announcement of the 1st position (Table H.4, Panel A) shows a negative market reaction for the energy sector in the narrow $(-2{,}2)$ event window surrounding the announcement date, with CAARs of -1.28% $(p \leq 0.05)$. This impact is primarily the result of mid-BE/ME, electric and big utilities. There is also a negative market response for low-BE/ME utilities in the $(1{,}10)$ window following the announcement, with CAARs of -1.43% $(p \leq 0.05)$. The negative market reaction is also present surrounding the announcement of the 2nd position (Panel B). High-BE/ME and natural gas utilities experience CAARs of -1.02% $(p \leq 0.05)$ and -5.18% $(p \leq 0.05)$, respectively. Moreover, the sector as a whole experience negative CAARs of -0.41% $(p \leq 0.1)$ in the narrow $(-1{,}1)$ event window surrounding the 2nd announcement, primarily the result of the underlying impact from big

---

[70] E.ON, RWE, Drax, GDF Suez, and EnBW

utilities. There is some positive impact preceding the signature date for the energy sector (Panel C), with CAARs of 1.59% ($p \leq 0.1$). This is mostly price corrections from natural gas and big utilities. However, the publication date (Panel D) has a negative impact across most portfolios, with CAARs up to -2.55% following publication.

Addressing ***H*₅**, the overall results show that the Security of Supply stream is negatively perceived by the market, but the impact is less clear compared with the other three streams. The results show a variety of positive and negative impacts through time, and there is no cross-sectional impact across portfolios. This suggests that the Security of Supply stream is difficult to process and that the impact is not fully known by the market; this is expected, as the legislation does not affect utilities directly.

6.4.3 Robustness Tests

6.4.3.1 Excluding confounding events

As highlighted in Section 6.3.3.1, some contemporaneous regulatory changes exist. Table 6.1 shows that the Internal Energy Market stream shares some stages of the regulatory process with neighbouring restructuring streams, such as the Energy Efficiency and Security of Supply streams. Contemporaneous regulatory changes have the potential for contaminating estimates of CAARs surrounding regulatory events. As argued, one remedy would be to delete the contemporaneous regulatory changes. However, this is unsatisfactory from a policy perspective, as the Internal Energy Market stream would lose both the second and third packages of liberalisation. Accordingly, the analysis continued with the contemporaneous observations to estimate market response in the days surrounding the announcement. This section of the diagnostic and robustness tests addresses the issue of contemporaneous observations.

The event study approach was repeated, omitting the event dates which had contemporaneous contaminations across restructuring streams; see Table 6.1. The results of the CAARs, tested across the same eight event windows, are presented in Table H.5 in Appendix H. In summary, the contemporaneous observations made little difference to the estimates of CAARs. Across the 64 significance tests, the results are qualitatively the same as those obtained, including the contemporaneous observations. Only five significance tests resulted in the magnitude of significance changing, but the results and direction remained consistent. Of the 64 tests, only two tests produced inconsistent results, discussed below.

The first inconsistent results relate to the removal of the third package of liberalisation, of which the announcement of the 1st position is contemporaneous to a Security of Supply announcement. When the event date is removed, the Internal Energy Market stream loses significance in the $(-1,1)$ event window surrounding the 1st position, and has a minor impact on the significance of two other CAAR estimates too. Overall, the impact is minor, as there is still significance on event day 0 and in the weeks preceding the announcement of the 1st position. This is due to the stream still containing the first and second packages of liberalisation. As stated previously, the third package is a major regulatory reform which is expected to have a large impact on internal competition in the energy sector. Accordingly, removing this package was expected to reduce the significance surrounding the announcement dates – observed in Table H.5. The removal of the date has a minor impact on the Security of Supply stream, but did not produce inconsistent results. The overall conclusion is that the legislation is weighted towards affecting the Internal Energy Market stream and had little impact on the Security of Supply stream (which was insignificant regardless).

The second inconsistent result relates to a series of Internal Energy Market and Energy Efficiency legislation which was contemporaneously voted, signed and published together. These events include the second packages of liberalisation, legislation regarding trans-national exchanges in energy and developing an energy efficiency programme for Europe. From a policy perspective, this chapter expects the internal energy legislation to be the most anticipated of the two competing streams. The results are congruent with expectations. When deleting the Energy Efficiency dates, the results are qualitatively unaffected. However, deleting the Internal Energy Market date resulted in a change in significance for the estimated coefficients. Removing the publication of the second packages of liberalisation resulted in the $(0,0)$ event window becoming significant at $p \leq 0.1$. Beyond these minor impacts, the results are generally consistent with those outlined previously.

6.4.3.2 Comparison of alternative models to the AFFM

Throughout this thesis, the econometric modelling has demonstrated that the local AFFM is superior in capturing variability in stock returns, for the European energy utility sector, in comparison with alternative specifications. Overall, the AFFM was superior at isolating the firm-specific component of returns in excess of the risk factors, controlling for a variety of stock market and commodity risk factors

As argued by Griffin et al. (2015) in Section 6.3.1.2, the number of control variables can influence the likelihood of Type I or Type II errors occurring. This section compares results from the AFFM specifications against those obtained using the CAPM, augmented-CAPM, and local four-factor model; see Section 5.3.1. The purpose is to examine the influence of commodities and/or stock market risk factors on the CAARs surrounding the four key stages of the ordinary legislative procedure. Fama and French (1993) argue that the stock market risk factors would be superior at isolating the firm-specific component of returns.

The CAARs surrounding each key stage are presented in Figure 6.8. The first observation regarding the results, across all key stages, is that there are two different distinct CAAR patterns produced depending on model specification. The CAPM and four-factor models produce similar CAARs to one another, while the augmented-CAPM and AFFM also produce similar CAARs. This leads to the conclusion that major differences in abnormal returns occur from the inclusion or exclusion of commodities, while the inclusion of stock market risk factors has almost no impact.

For the 1st position (Plot A), the comparison of the four asset pricing models shows that commodities have a large role in determining abnormal returns surrounding the event. For both the CAPM and four-factor specification, the CAARs fluctuate close to zero through the entire event window and would result in a false negative – where results would indicate no abnormal performance surrounding the 1st position. Controlling for commodity risk factors, using the augmented-CAPM and AFFM shows that CAARs have greater negativity surrounding the 1st position. Moreover, the stock market risk factors also appear to influence CAARs in the weeks prior to the announcement. The results indicate that firm characteristics, as measured by stock market factors, are important determinants of expected returns prior to the announcement and commodities have an increasing role in performance after the announcement. The difference between CAARs of the CAPM and Augmented-CAPM is -1.19%, while the difference between the four-factor and AFFM is -1.21%. In both cases, the difference is determined by including or excluding term premium and commodity variables. This would be consistent with Oberndorfer (2009a), who argues that investors benchmark utilities against commodities. This may also be associated with periods where investors are processing the likely impact of the potential regulatory change, and therefore seek risk factors which may determine expected returns. Commodities appear to ‘support’ energy utility stock prices in times of uncertainty.

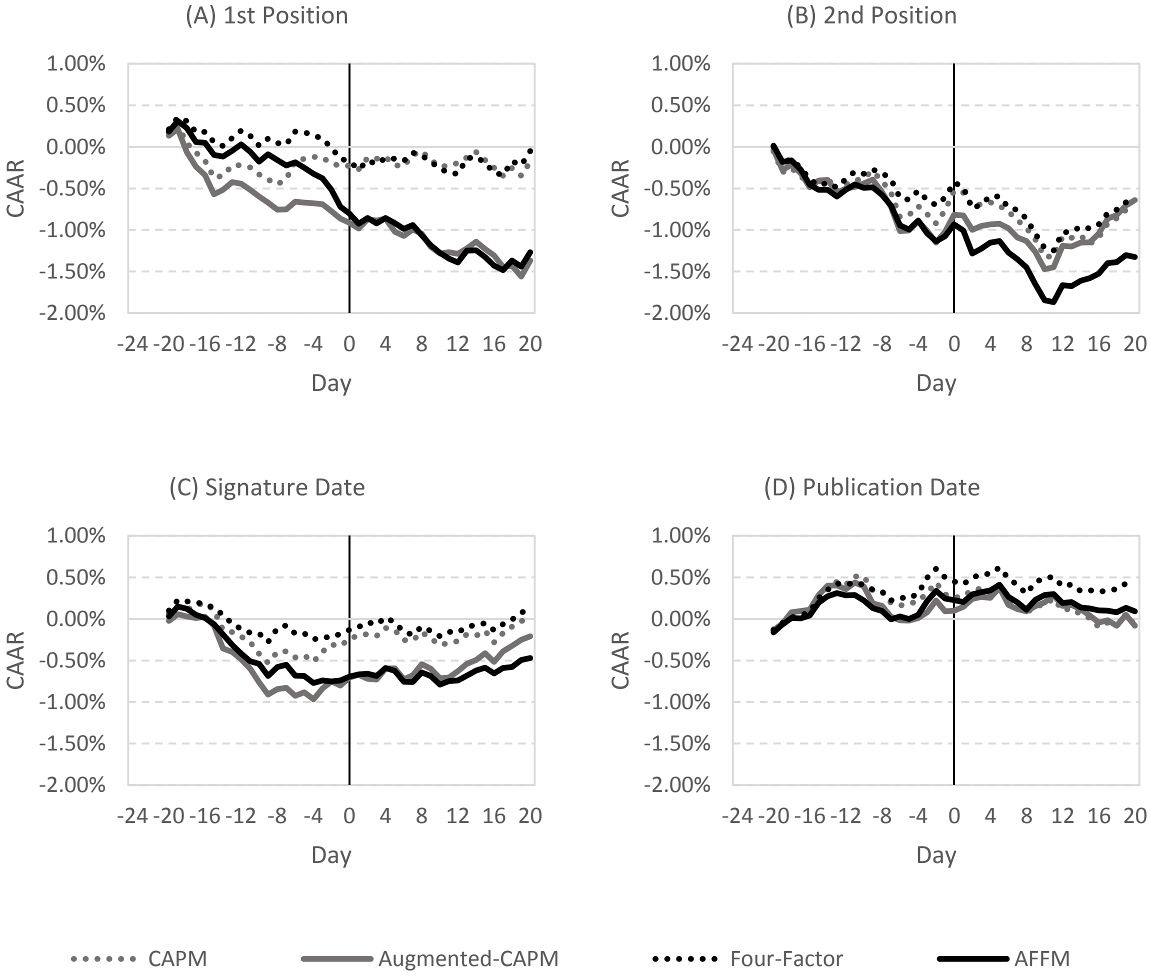


FIGURE 6.8: COMPARISON OF EVENT STUDY USING VARIOUS ASSET PRICING MODELS

The figure shows the CAARs extracted from the event study approach for the energy sector portfolio, using four different asset pricing specifications: the CAPM, augmented-CAPM, local four-factor model, and the localAFFM. Specifications which include term premium and commodities are represented with a solid line, while specifications which omit term premium and commodities are represented with a dotted line. Grey lines represent the CAPM specification and the augmented extention, while the black lines represent the local four-factor specification and the augmented extention.

Regarding the 2nd position (Plot B), the impact of stock market factors and commodities is less pronounced. Overall, the four asset pricing models produce similar results. The CAPM and four-factor models are near identical through time, whereas the augmented-CAPM and AFFM begin to differentiate after the announcement of the 2nd position. Overall, the greatest difference in CAARs is -0.68%, were the AFFM produces the most negative CAARs. By the 2nd position, the market has had time to process the information content of the regulatory change, and commodities lose their benchmarking role in stock valuation.

Surrounding the signature date (Plot C), there is some minor decoupling between stock market factors and commodity factors. This occurs during the legal-linguistic stage, where informational content and legal definitions are determined. Again, there is the potential for uncertainty regarding the finalisation of the legislative text during this event window. In the weeks preceding the signature date, there is some minor impact from stock market factors and commodities. However, the four specifications do not deviate more than 0.75% from each other, and the CAARs remain relatively stable after the signature date.

The publication date (Plot D) is expected to have little to no impact on CAARs, as all the informational content regarding the regulatory change should already be impounded into stock prices. As expected, all four model specifications produce similar CAARs, showing that stock market and commodity risk factors are relatively unimportant at this stage.

Overall, the robustness tests above show support for Griffin et al. (2015), namely that the controls specified can increase the likelihood of errors. However, the majority of this impact, for this thesis, will occur surrounding the 1st position and, to a lesser extent, the signature date. We are inclined to conclude that the AFFM is the most accurate specification regarding how regulatory changes affect the firm-specific component of returns. There is a wealth of literature in Chapter 3, combined with the results of Chapters 4 and 5, that shows commodities have sustained or sporadic significance through time – depending on their use in energy production – and that commodities affect asset valuation of commodity-related industries. Further, the results of the local AFFM capture the greatest proportion of returns through time. To isolate the impact of the regulatory changes on a firm, the commodities must be controlled for during the event study procedure. As demonstrated above, a failure to control for commodities will often result in false negative results.

6.5 Conclusions and Policy Implications

This chapter presented an empirical model which links the impact of regulatory changes to the stock returns of energy utilities. Specifically, this chapter examined the timing of the market's response surrounding key stages of the EU ordinary legislative procedure and explores the market's unique response to the four distinct restructuring streams: Internal Energy Market, Energy Efficiency, Renewable Energies and Security of Supply. The event study was implemented using the local AFFM developed in Chapter 5. This asset pricing model controls for stock market risk factors (the market factor, size premium, value premium and momentum premium), term premium and commodities (oil, coal and natural gas). This chapter addressed two sets of hypotheses. The first hypothesis predicts that the market's reaction will occur surrounding the early co-decision stages of the legislative procedure. The latter four hypotheses predict negative impacts for each of the four restructuring streams, addressed independently.

Consistent with the first hypothesis, the results showed the market reaction regarding regulatory changes in the energy sector is found to predominantly occur surrounding the early voting stages of the legislative procedure, at the announcement of the 1st and 2nd positions. The later stages of the legislative procedure, including the signature and publication dates, have no significant impact on the energy sector as a whole. While there was some within-sector heterogeneity, the results imply that the market efficiently prices regulatory risk for energy utilities. Investors are closely monitoring the legislative procedure and efficiently incorporating information into asset prices. This is an important methodological and academic contribution, as it has implications regarding measuring the impact of regulatory changes in the context of the EU's ordinary legislative procedures more generally (i.e. beyond the current focus on the energy sector). The results in this chapter show that the majority of the impact occurs prior to the political institutions' announcing their voting positions, implying that the market is either anticipating information early or speculating on the likely outcome of the vote. These results are consistent with the open, transparent objectives of the legislative procedure (see Section 2.1), but suggests that the informational content of the legislative proposal is irrelevant by the time it is press released.

The second set of hypotheses test the differential market reaction surrounding the four restructuring streams, each expected to have a unique impact on the stock prices of European energy utilities. The first restructuring stream, the Internal Energy Market stream, is typically associated with liberalisation objectives. This chapter hypothesised that the stream would have a negative impact on energy utilities. The results for the Internal Energy Market Stream show that the negative market reaction primarily occurs in the weeks surrounding the announcement of the 1st position. The efficiency of market reaction is due to the lengthy consultation process, which may last years, and the potential impact on firm valuation – especially in the case of legally unbundling companies. This stream fundamentally changes the regulatory and operating environment of utilities, and is therefore the most likely to be anticipated. The announcement of the 1st position sends a strong signal to the market that the proposal, trilogues and consultations are near finalisation, and the finalised text is agreeable between the two voting political institutions (the Parliament and the Council). Unsurprisingly, the negative impact is principally focused on big and natural gas utilities, which lose market dominance and are at risk of asset stranding.

The second stream, the Energy Efficiency stream, focuses on reducing energy demand by reducing the energy consumption of appliances and properties at the user end of the supply chain. The chapter hypothesised a negative impact due to the reduction in potential future revenue. The Energy Efficiency stream has a negative impact on nearly all utilities tested, and the impact primarily occurs prior to the announcement of the 2nd position. Results are congruent with expectations that the declining size of the energy market will decrease potential revenue in the future.

The Renewable Energies stream is designed to increase use of renewable energies in energy production, and also sets minimum targets for the electrification of the transport sector by 2020. The renewable energy objectives are frequently cited as the primary reason energy utilities have lost value over recent decades (see Section 1.2). This chapter hypothesised a negative impact from renewable energy objectives due to the decreased reliance on hydrocarbons, but included a caveat that the impact is likely to be contained within natural gas utilities as electricity utilities can adapt operations. Unsurprisingly, very few energy portfolios were affected by the renewable energy legislation, with the impact mostly being limited to natural gas utilities. Natural gas utilities lose potential market share from the electrification of transport, while any gas-fired electricity-generating plants may be underutilised as consumers switch to renewables suppliers, or the plants are forced to invest in renewable energy–based technology which they have little experience of. Some electricity and multi-utilities experienced a negative market reaction, but the reaction either showed some correction in subsequent windows or was still relatively small compared with the losses from the natural gas industry.

Finally, the Security of Supply stream focuses on diminishing the harmful effects of securing oil and petroleum (including by-products) within Europe. While the intention of the regulatory changes is designed to benefit society, prior empirical evidence has shown that the returns of energy utilities have a positive relationship with oil prices and volatility, despite oil rarely being used in energy production. Accordingly, this chapter hypothesised that regulation to limit abnormal oil price increases will negatively impact the energy sector. The main results show that the impact of the Security of Supply stream was relatively low in comparison with the remaining three streams. Empirical results from the event study demonstrate that the market negatively reacts to legislation concerning security of the oil supply. Results mostly show negative market reactions surrounding the announcement of the 1st position and following the publication date. There is some minor price correction occurring between these dates. The conclusion is that the impact is difficult to gauge, as it does not affect utilities directly.

Addressing the overarching results, the results of this chapter are consistent with the existing energy economics and regulation literature in Sections 3.3.2 and 3.3.3. As expected, the liberalisation objectives (see Section 2.2.1) mostly had a negative impact on the energy sector. Liberalisation and deregulation have brought about competition, additional expenses to operations and exposed utilities to the real threat of bankruptcy. However, small utilities eventually benefit from these regulatory changes, either from their exclusion from the legislation or from the new regulatory environment which encourages entry into markets by small new competitors which are often renewables-only companies. Overall, liberalisation objectives appear to be diminishing the market power of big utilities by encouraging entry by some of their small/new entrant rivals. However, the objectives are far from complete, and there is already demand for a fourth package of liberalisation; see FSR Energy (2015).

The environmental objectives (Sections 2.2.2 and 2.2.3) have also negatively impacted the sector as a whole. However, in contrast to press assertions, the results have found that the Energy Efficiency stream was the most significant determinant of negative abnormal returns rather than renewables. Unsurprisingly, the reduction in energy consumption per capita as a result of the Energy Efficiency stream will intensify competition for the energy supply, where the impact is realised cross-sectionally in the energy sector. In contrast to the press's critical claims regarding the impact of renewables on the energy supply (see Section 1.2), the impact of renewables generally had lower significance and was mostly limited to natural gas utilities. This impact for natural gas utilities is likely due to their undiversified operations and limited options to adapt operations. By way of contrast, prior studies have shown that fuel-switching has been a viable option for the electricity sector, with such behaviour being apparent in Western Europe since the 1960s (see Söderholm, 1998; 2001). Interestingly, natural gas utilities were generally the most negatively impacted portfolio across most regulatory changes.

This latter point indicates that the press is subject to focalism, where the negative impact for the gas-majors are erroneously extrapolated to the entire energy sector. Superficially, this bias can be justified to some extent as the gas majors typically represent some of the largest energy utilities in the EU; therefore, any impact to their valuation can also influence total sector valuation. However, as one utility falls out of favour, another will take its place. Rather than solely focusing on the myopic impacts of regulation today, the questions regarding the regulation of the sector should be framed in the context of designing the energy system of the future – namely, which utilities have the potential to grow and fulfil the EU's future energy demand? With this perspective, the results of this chapter suggest a viable future for small utilities in the EU energy utility sector, which have already begun to see increasing share prices as a result of regulatory changes. Clearly, the market has also begun to recognise the positive regulatory environment for smaller utilities.

6.5.1 Contributions

Placing this research in a broader context, it is noteworthy that the European utilities sector has been subject to wide spread criticism in the popular media because it is perceived that it has been profiteering at the expense of end consumers (see Section 1.2). The evidence presented shows that their risk-return trade-off has fundamentally changed as a result of sector liberalisation and environmental policies. The restructuring of the energy sector has induced additional elements of risk into the sector. As such this chapter has provided rigorous support (to some extent) to the claims made by The Economist (2013b), in their article ‘How to lose half a trillion euros’, that utilities now face a range of policy induced challenges that are materially affecting their financial return. However, it is not only renewable energy policies which affect financial return, but also liberalisation, energy efficiency and security of supply policies too.

Critically, the impact of the policy streams implies an increased cost of equity capital for energy utilities, negatively impacting their ability to raise the estimated $2.2 trillion of total power sector investment needed in the EU between 2014 and 2035 (IEA, 2014). Thus, this chapter highlights a tension between policy objectives, in particular liberalisation and environmental objectives. The point is not to abandon liberalisation or even environmental objectives, nor is it to recommend an overhaul of the legislative procedure, but it is important to acknowledge that tension exists between different pieces of legislation and within the legislation procedure. EU institutions should bear in mind that the policy mix utilities are being exposed to is making it harder to achieve decarbonisation goals. There are potentially many ways Brussels can help, ranging from providing a stable regulatory environment to ensuring governments are co-investors or underwriters of projects. This chapter does not recommend any one particular solution; rather, the aim is to highlight that Brussels needs to ensure its policies are consistent across different policy goals. This thesis’ evidence suggests this is not the case currently.

From a more academic and more general policy perspective, this chapter has contributed to the literature by providing a better understanding of how and when stock prices are generally affected by regulatory changes, but especially in the context of the EU ordinary legislative procedure – a procedure that affects 503 million EU citizens[71] and represents the largest economy in the world.[72] The results of the chapter suggest markets are efficient at incorporating the effect of regulatory change and that rational heterogeneous market reactions

---

[71] 2014 data extracted from EUROPA: http://europa.eu/about-eu/facts-figures/living/index_en.htm

[72] 2014 data extracted from EUROPA: http://europa.eu/about-eu/facts-figures/economy/index_en.htm and http://ec.europa.eu/trade/policy/eu-position-in-world-trade/

exist depending on the types of legislation proposed and the company affected. The overall conclusion of market efficiency is important, since inefficient markets create arbitrage opportunities which can negatively impact uninformed market participants and the valuation of firms (Griffin et al., 2015).

6.5.2 Limitations

As demonstrated in the robustness tests (Section 6.4.3), this event study approach is not without criticism. The ordinary legislative procedure is lengthy, complex and entirely public; therefore, it is not possible to examine the impact of 'pure' events. Information will continually filter into the market, and so the impact is not as distinct as one would desire for econometric analysis. Further, legislation from different restructuring streams is simultaneously discussed, voted upon, amended and published. While this is a limitation, it should not be an obstacle to empirical analysis. This criticism will exist regardless of the empirical modelling technique adopted. As researchers, the best option is to acknowledge that such limitations exist when analysing real world data and attempt to control for these confounding variables as thoroughly as possible. This chapter has implemented the most comprehensive analysis of the ordinary legislative procedure, narrowing the timing of information incorporation into four suspected event dates.

CHAPTER 7

CONCLUSION

7.1 Introduction

This research contributes to a better understanding of how risk factors are affecting the returns of European energy utilities. From a policy perspective, this thesis focuses on the liberalisation and decarbonisation of the energy sector, which represent two key policy issues at the EU level over the last few decades and remain central to EU policy agendas today. The risks associated with sector liberalisation and decarbonisation have led to debates on the economic merits of restructuring the sector, particularly given the impact these reforms are argued to have had on the valuation and financial return of energy utilities.

From an academic perspective, this thesis expands the asset pricing literature by reintegrating macroeconomic variables and stock market risk factors from the energy economics and finance literatures, respectively. The thesis extends the asset pricing model further by including recent advances in the econometrics literature to examine the assumption of parameter stability, including deductive annual regressions and the inductive Bai and Perron (1998; 2003) structural break point test. This thesis enhances the understanding of risk premia in the European energy utility sector by: 1) providing a full outline of the ordinary legislative procedure for the European Union (Section 2.1); 2) outlining four distinct restructuring streams (Section 2.2); 3) integrating the finance (Section 3.2.2), energy economics (Section 3.2.3) and econometrics (Section 3.3.4) literatures to produce a superior asset pricing model for the energy sector; and 4) conducting an event study analysis on the timing of market reaction in the ordinary legislative procedure and measuring the impact of the four restructuring streams. Using a broad sample and list of regulatory events, the thesis conducts three empirical studies, including:

1) **Risk factors in energy utility returns: an augmented-four-factor model (AFFM),**
2) **Refining the AFFM and exploring within-sector heterogeneity,**
3) **The impact of regulatory changes in energy utility returns.**

This concluding chapter summarises the three empirical chapters and outlines academic and policy contributions of the thesis. This chapter is structured as follows. Section 7.2 provides a brief summary of the chapters. Section 7.3 outlines the academic contributions of the thesis, while Section 7.4 outlines the policy contributions. This chapter concludes by outlining thesis limitations and avenues for further research (Section 7.5).

7.2 Summary of the Three Empirical Chapters

The three empirical chapters (Chapters 4, 5 and 6) are discussed in turn. Chapter 4 develops a global AFFM by reintegrating energy economic and finance asset pricing models to answer four research questions, namely: 1) To what extent do commodity price changes impact the returns in the European energy utility sector? 2) Could stock-market risk factors better explain the variation in energy utilities' returns? 3) Do the impacts reflect market-wide conditions or the sector-specific relationships between returns and risk premia? and 4) Are these risk premia time-varying? The motivation for Chapter 4 came from El-Sharif et al. (2005) and Oberndorfer (2009a), who argue that the energy economics literature is restricted due to its reliance on antiquated asset pricing models. Both studies identify that the incorporation of standard finance risk factors as an avenue for further research. The motivation for the inter-sectoral approach is based on evidence of heterogeneous impacts of risk factors across multiple industries, also identified by Fama and French (1997), Faff and Brailsford (1999), El-Sharif et al. (2005) and Elyasiani et al. (2011). Further, the inter-temporal approach is motivated by evidence of temporal sensitivity to risk factors, affecting significance (Huang et al., 1996; Fama and French, 1997; Faff and Brailsford, 1999; Sadorsky, 2001; El-Sharif et al., 2005; Boyer and Filion, 2007; Oberndorfer, 2009a). Chapter 4 develops the global AFFM by calculating risk factors across a diversified sample of 600 European firms (see Section 4.2.4). An unconditional global AFFM is applied between 1996 and 2013 across 11 European sectors (see Section 4.2.3.1), identifying inter-sectoral sensitivity to risk factors. The conditional global AFFM is applied annually between 1996 and 2013 to identify inter-temporal sensitivity. The results are extensively discussed in Section 4.3. Having defined the global AFFM, Chapter 5 focuses on refining the AFFM and improving the model's goodness of fit through four analytical foci – producing the local AFFM.

Chapter 5 further enhances the understanding of energy sector asset pricing through four analytical foci that develop a more nuanced understanding of the impact of risk factors on sector returns, namely: 1) refining the global AFFM by calculating stock market risk factors at the sector level, creating a local AFFM; 2) applying the local AFFM to sub-group portfolios of European utilities to explore within-sector heterogeneity; 3) applying inductive rather than deductive structural break point tests (see Section 3.3.4); and 4) better isolating the firm-specific component of returns. The motivation for the sector level analysis came from the literature review in Section 5.2, which argued there may be greater informational content *within* a sector compared with informational content across an entire market. Prior literature found evidence that global models typically perform poorly at explaining sector level returns and local models improve the model's goodness of fit (Moskowitz and Grinblatt, 1999; Fama and French, 2012). Further, the motivation for an inductive break point test came from econometrics literature which argues that the deductive approach biases significance tests (Quandt, 1960). Chapter 5 introduced recent advances in econometrics which develop an inductive method of estimating pure and partial structural break points in model parameters (see Section 3.3.1), which better controls for systematic risk and is better at isolating the firm-specific component of returns (Fama and French, 1993; Hansen, 2001). The results of Chapter 5 are discussed extensively in Section 5.4. For the European energy utility sector, the local AFFM is found to have tighter regression fits than the global AFFM and existing asset pricing model specifications. For this reason, Chapter 6 utilises the local AFFM to analyse the impact of regulatory changes on sector returns.

Chapter 6 utilises an event study approach to examine how the returns of the energy utility sector have been impacted by a myriad of regulatory changes. The motivation for Chapter 6 came from the need to objectively quantify whether there has been some fundamental shift in the operating or regulatory environment of energy utilities that may explain their altered returns. Importantly, the EU has begun to transform the energy sector from one largely dominated by vertically integrated, state-owned enterprises with regional monopolies, to an unbundled, privately-owned and competitive energy sector. Environmental objectives of the EU include: 1) reducing overall EU energy consumption by increasing the efficiency of end-user appliances and homes, with an expected decrease of energy demand of 10% to 20% by 2050 (Delarue et al., 2011); and 2) reducing EU-wide carbon emissions by increasing the use of renewable energy sources. Finally, security of supply objectives has attempted to partially regulate oil prices and diminish the harmful effects of securing oil and petroleum at the EU level.

All the regulatory changes above are subject to a protracted and complex legislative procedure (see Section 2.1). To examine the impact of regulatory changes with precision, the timing of market reaction surrounding regulatory announcements must first be explored. Accordingly, Chapter 6 addresses two research objectives: 1) exploring the timing of market reaction surrounding key stages of the legislative procedure and 2) exploring the market's unique response to the four distinct restructuring streams identified in Section 2.2 (namely, the Internal Energy Market, Energy Efficiency, Renewable Energies and Security of Supply). The two overall research objectives are addressed through five hypotheses: the first hypothesis predicts that the market's reaction will occur surrounding the early co-decision stages of the legislative procedure (the voting stages); the latter four hypotheses predict negative impacts for each of the four restructuring streams, addressed independently. The results of Chapter 6 are discussed in Section 6.4.

The following sections outline the cross-chapter thesis contributions. Section 7.3 presents the academic contributions, delineated into methodological and general contributions. The policy contributions are presented in Section 7.4, including sector-wide policy implications for the energy sector (Section 7.4.1) and heterogeneous implications regarding energy utilities (Section 7.4.2).

7.3 Academic Contributions

This section contains the overarching discussion of the academic contributions of the three empirical studies. The following paragraphs presents the methodological contributions with regard to the asset pricing models and impact of regulatory changes at the sector level. The final paragraph presents more general contributions from the thesis.

Methodologically, Chapter 4 contributes to the literature by developing the AFFM. Compared with existing asset pricing models, the global AFFM of Chapter 4 provides the best overall goodness of fit across various European sectors, with a mean adjusted R^2 of 75.99%, compared with the CAPM (72.44%), the augmented-CAPM (72.56%) and the four-factor model (75.90%). The inter-sectoral comparison using the global AFFM found varying coefficients for risk factors across sectors. Results for the energy utility sector shows sector-specific relationships with risk premia, rather than market-wide conditions across all sectors. Importantly, the returns profile of the energy sector is distinct to the oil & gas sector and warrants independent analysis. The most striking feature is that a simple sorting according to firm size, book-to-market ratio and momentum draws out important stock market risk factors which were previously obscured within the market factor. Overall, the global AFFM helps establish a more accurate equilibrium asset pricing function, allows inter-sectoral comparison of risk premia and has implications for modelling average returns at the sector level.

When examining the energy sector in isolation, the local stock market risk factors of Chapter 5 improve the AFFM further, explaining a greater proportion of energy sector returns compared with global (market level) stock market risk factors. The adjusted R^2 for the energy sector increases from 68.79% using the global AFFM to 72.77% using the local AFFM. The results of Chapter 5 contribute to the literature by showing that there is greater informational content *within* a sector, compared with informational content across an entire market. This approach helps improve the accuracy of estimated coefficients with regard to risk premia in the energy utility sector. Second, the combination of the local AFFM and 12 energy portfolios (see Section 5.3.2.1) enabled a detailed examination of sector level returns and within-sector heterogeneity, which shows that the risk profiles of energy utilities vary dramatically depending on firm characteristics. The improved asset pricing model helps establish a more accurate equilibrium asset pricing function, for the sector as a whole or for individual energy portfolios.

Chapter 5 also shows that the assumption of parameter stability is incorrect. Chapter 5 extends the asset pricing literature by including modern advances from the econometrics literature, namely, the Bai and Perron (1998; 2003) inductive structural break point test. The Bai and Perron (1998; 2003) inductive structural break point test overcomes many of the existing criticisms regarding the use of deductive methods to control for parameter instability. This chapter utilises the Bai and Perron (1998; 2003) test in two ways.

First, the local AFFM break point regression shows significant structural breaks in the relationship between energy sector returns and risk premia. Addressing parameter stability, the inductive method improves the local AFFM's goodness of fit further, producing an adjusted R^2 of 80.42%, compared with the mean adjusted of R^2 of 74.52% for the deductive annual regressions using the local AFFM (Chapter 5), and 69.64% for the annual regressions using the global AFFM (Chapter 4). Second, Chapter 5 utilises the inductive structural break point test on the local AFFM's residuals, showing that up to 28% of residual variance from an unconditional regression on energy utilities is explained by systematic risk factors (previously assumed to be filtered out). The inference of this result is that failure to control for this time-varying nature in the relationship between average returns and risk premia leads to incorrect inferences on the firm-specific component of returns. Chapter 5 makes a novel contribution to the asset pricing literature in terms of identifying unsystematic, firm-specific components of return. Moreover, this chapter provides a flexible tool which can be adapted to other sectors, since it suggests a method of more accurately examining time-varying risk premia and isolating the firm-specific component of returns for any sector. Overall, the local AFFM can be used in applications that require estimates of expected stock return, including 1) portfolio selection, 2) evaluating portfolios performance, 3) estimates of cost of capital and 4) measuring abnormal return in event studies (Fama and French, 1993).

Chapter 6 makes two academic contributions. First, results showed the market reaction regarding regulatory changes in the energy sector predominantly occurs during the early voting stages of the legislative procedure: surrounding the announcement of the 1st and 2nd positions. While there was some within-sector heterogeneity, the results imply that investors are closely monitoring the legislative procedure and efficiently price regulatory risk for energy utilities. This has implications regarding measuring the impact of regulatory changes in the context of the EU's ordinary legislative procedures more generally (i.e. beyond the current focus on the energy sector). Second, the chapter shows that the energy sector's risk-return trade-off has fundamentally changed as a result of sector liberalisation and environmental policies, which shows that utilities now face a range of policy-induced challenges that are materially affecting their financial return.

Finally, this thesis has also made more general contributions beyond the econometric results. First, Chapter 2 presents an overview of the European ordinary legislative procedure, and examines the timing of market reaction and market efficiency. The complexity of the procedure has been simplified into four key stages and examined using appropriate event study methods. Second, Table 2.1 represents a broad range of regulatory changes to date, allowing thorough examination of the impact of legislation on energy sector returns. Third, this thesis dramatically increases the sample size of European energy utilities used in the empirical analysis relative to the existing literature. The thesis includes 88 European utilities, across all operations of the electricity and natural gas industries, which also controls for survivorship bias. The analysis is also conducted between 1996 and 2013. This represents a marked improvement of sample size and time period analysed relative to existing literature, including El-Sharif et al. (2005), Oberndorfer (2009a) and Koch and Bassen (2013). Further, the energy sector as a whole is compared with other European sectors, extending El-Sharif et al. (2005). Fourth, this thesis delineates the 88 energy utilities into various portfolios grouped on firm characteristics, and rebalances the portfolios over time. In particular, this thesis introduced the industry portfolios, delineating energy utilities in electricity, natural gas and multi-utilities. The 12 energy portfolios of Chapter 5 represent the most in-depth analysis of returns in the energy sector to date.

7.4 Policy Contributions

The following section outlines the policy contributions of the thesis. Section 7.4.1 presents the sector-wide contributions with regard to the entire energy sector, while Section 7.4.2 presents contributions based on firm characteristics.

7.4.1 Sector-wide Contributions

As stated in Section 1.2, the energy utility sector has been a topic of intense debate about perceived excess accounting returns and oligopoly power in the European energy sector. It is argued that these energy companies are making excess returns at the expense of the consumers, but often the risk borne by energy utilities is overlooked. The objective of this thesis is to quantify whether there has been some fundamental shift in the operating or regulatory environment of energy utilities that may explain their altered returns. The thesis examined new risks arising from liberalisation and environmental objectives.

The analyses in Chapters 4 and 5 have empirically shown that the energy utility sector is taking on increasing systematic risk over time, as indicated by the market beta increasing towards unity. The changing nature of the energy sector as a result of restructuring has put into question utilities' role as a steady, reliable and defensive investment asset. As such, investors are expecting greater compensation for holding energy assets and taking a more active role in trading into and out of energy utility positions in response to regulatory changes. The intertemporal analysis in Chapters 4 and 5 show that this coincides with major changes in systematic risk. This would suggest that the higher returns afforded to energy utilities may, in some part, be explained by increased market risk. However, the following paragraphs show that energy utilities have also been exposed to additional risks beyond the market factor.

The analysis in Chapters 4 and 5 (Tables 4.7, 5.8 and 5.10) show that the impacts of stock market risk factors have also changed over time. In contrast to the objectives of liberalisation, aimed at countering market dominance from big utilities, the big energy utilities continue to dominate sector returns with an increasing impact over time. This is a major blow for liberalisation policy (see Section 2.2), since it was supposed to benefit small and new-entrant companies. The empirical results suggest that the regulations have been ineffective and large utilities continue to dominate sector returns. This lack of effectiveness is already recognised by academics, with FSR Energy (2015) already conducting informal debates with respect to a fourth package of liberalisation – continuing to address unachieved liberalisation objectives.

From a policy perspective, the value premium coefficient shows that the energy utility sector, as a whole, is relatively distressed in comparison with other European sectors (see Table 4.5). This was also shown in Section B.2 of Appendix B. Further, Table 4.7 shows that there is increasing value premium over time, relative to other European stocks, suggesting that the sector has become even more distressed since 2011.

The local momentum premium in Figure 5.2 (Plot C) shows that prior to 2000 there were few differences between winners and losers, but as liberalisation progressed there has been a growing gap between winners and losers in the energy sector. However, the inter-temporal momentum coefficients (Tables 4.7 and 5.8) show that the sector performs poorly in the years following major regulatory changes, suggesting that regulations are having an impact on sector returns. This suggests that, to some extent, competitive pressures are achieving their intended objectives: to expose energy utility inefficiencies and slowly phase out poorly performing utilities. However, further investigation is required to examine which utilities become 'winners' and which become 'losers'. It is plausible that the winner portfolio contains utilities that continue to exert market dominance, rather than the green-energy utilities the EU aims to transition towards. Since the EU is considering a fourth liberalisation package, this can be taken as tacit acknowledgment that the efforts to date have not resulted in the competitive market desired.

This thesis has also shown that term premium and commodities typically have a small impact on energy sector returns, but the frequency and magnitude of commodity risk exposure is increasing as liberalisation progresses. The inclusion of stock market risk factors typically reduces the significance of some commodities, indicating that inferences drawn from previous literature may be based on *false positive* results. In particular, Table 4.4 shows that coal returns are correlated with the global value premium – a measure of firm distress. However, the ability to detect any commodity price risk suggests that energy utilities have not fully realised the benefits of energy risk management. This raises questions as to why energy utilities have not been able to hedge effectively (addressed in Section 7.4.2). Similar to momentum, the impact of commodities mostly occurs as sector restructuring progresses. Therefore, we examined the impact of regulatory changes on the energy sector.

This thesis is the first to empirically show the timing of market reaction during the EU’s protracted legislative procedure, and the impact of the four restructuring streams. The results show that nearly all utilities are exposed to the Internal Energy Market (liberalisation) and Energy Efficiency (environmental) streams. The Internal Energy Market stream fundamentally changes the regulatory and operating environment of utilities. The qualitative nature of the legislation requires lengthy consultations and informal trilogues between European political institutions. The acceptance of the proposal by one of the two institutions sends a strong signal that the proposal is near finalisation, and therefore likely to be anticipated by the market. It is also expected that investors are more likely to anticipate a sector-wide announcement due to the potential transfer of wealth; congruent with Binder (1985). Empirical results confirm this proposition. This thesis shows, empirically, that the market reacts at the announcement of the 1st position, and the impact is observed across nearly all energy utilities. The Energy Efficiency stream shows similar results. The Energy Efficiency stream was expected to have a cross-sectional impact as the stream reduces energy consumption of EU citizens per capita, affecting all utilities. This thesis shows that the impact of the Energy Efficiency stream occurs surrounding the announcement of the 2nd position. Across both streams, the results imply that investors are closely monitoring the legislative procedure and efficiently price regulatory risk for energy utilities.

Importantly, this thesis shows that the press, such as The Economist (2013a; 2013b; 2013c; 2015) and The BBC (2013), is subject to focalism. The press has argued that renewable energy objectives have negatively impacted the valuation of the EU energy utility sector. This thesis has empirically shown that investors, in fact, react primarily to liberalisation and energy efficiency objectives. The results also show that the impact of renewables is typically isolated to a specific subset of utilities (discussed further below).

7.4.2 Heterogeneity

Beyond the sector-wide results, this thesis provides an in-depth examination of within-sector heterogeneity to risk factors and regulatory changes. Regarding the risk factors, the local AFFM of Chapter 5 showed substantial heterogeneity in the return profiles of the 12 energy portfolios tested. Regarding the risk factors, heterogeneous sensitivity to size, value and momentum premia were the largest determinants for the differences in expected returns across various energy portfolios. The stock market risk factors resulted in the largest spread in estimated coefficients, and expected returns varied by 4.60-8.48% per annum between energy portfolios. Term premium and commodity risk factors showed relatively little impact, with a small spread in estimated coefficients and a difference in expected returns, across all energy portfolios, being less than 0.87% per annum. Some portfolios have greater commodity risk exposure than others.

For the most part, each energy portfolio showed unique risk exposure. Regarding the size portfolios, small utilities have lower systematic risk but greater commodity risk exposure compared with big energy utilities. The results show that commodities play a key role as an indicator for energy price developments when valuing informationally sparse stocks, such as small utilities; see Kumar (2009) and Oberndorfer (2009a). This increased commodity risk exposure could also indicate that small utilities are not hedging effectively. This places small utilities in a dangerous position, as there have been dramatic changes in the price of energy-related commodities over the last decade, with record high prices for oil, natural gas and coal (Oberndorfer, 2009a).

It is surprising that small utilities, which are typically associated with being marginal or distressed firms, have not chosen to fully protect themselves from commodity price volatility through hedging instruments and strategies. There are several possible reasons for this. First, as hedging represents an insurance against price volatility, it is possible that utilities could ultimately pay above-market rates if the market for the energy commodity falls below the hedged price. Second, Figure 4.3 (Plots F, G and H) shows that commodity prices have been increasing over the past two decades. It is possible that smaller utilities are altering endogenous risk exposure and speculating on commodity prices with the objective of supplementing income through arbitrage; congruent with Söderholm (2001). The third possibility is that the small utilities lack the capital, expertise or access to derivative markets to hedge effectively. Regardless of the cause, there needs to be thorough investigation into why the small energy utilities are more exposed to commodity risk.

Regarding firm operations, the asset pricing models show that the electricity industry is relatively distressed compared with other utilities, as evident in the higher cumulative returns in Figure 5.2 (Plot D) and greater commodity risk exposure. The results in Table 5.5 show that all commodities are statistically significant for the electricity industry. Electricity utilities have the greatest commodity risk exposure compared with natural gas- and multi-utility portfolios. Similar to the arguments above for small utilities, there may be a variety of reasons why electricity utilities choose to, or are unable to, hedge against commodity risk. Regardless of the cause, the increased risk exposure of electric utilities makes the likelihood of achieving ambitious decarbonisation goals less likely. As argued above, the increased risk exposure will result in investors expecting greater competition for holding energy positions.

In contrast to the increased risk for electricity utilities, this thesis showed that the natural gas industry was the only energy portfolio to experience positive momentum over the full-periods (see Table 5.5), suggesting historically good performance or implies excess profiteering (argued in Section 1.2). Further, the natural gas portfolio shared many similarities with the oil & gas sector of Chapter 4, being positively impacted by oil and natural gas price risk, but is likely due to the integration of natural gas and oil operations. Multi-utilities had the lowest risk-return relationship of all energy industries and shared elements of risk exposure with both electricity and natural gas utilities, consistent with the economy of scope argument and the ability to diversify operations. The diversified operations allow multi-utilities to switch operations when faced with regulatory changes or fluctuations in commodity prices.

This thesis showed heterogeneous impacts for regulations. While the liberalisation stream affected most energy utilities, the negative impact was larger for big and natural gas utilities, which lose market dominance and are at risk of asset stranding, respectively. Simultaneously, small utilities are experiencing positive returns as a result of liberalisation objectives. Liberalisation objectives appear to be diminishing the market power of big utilities by encouraging entry by some of their small/new entrant rivals, but liberalisation objectives are far from complete. Despite being frequently cited as the primary reason energy utilities have lost value over recent decades, the impact from renewables has mostly being limited to natural gas and hydrocarbon intensive utilities. Natural gas utilities lose potential market share from the electrification of transport, while any gas-fired electricity generating plants may be under-utilised as consumers switch to renewables suppliers, or the plants are forced to invest in renewable energy-based technology which they have little experience of.

Overall, the impacts of regulatory changes are partially consistent with the claims of press. While the energy sector as a whole is losing value, this is predominantly due to the fact that the big utility giants are negatively impacted by regulatory changes and their combined value represents 93.4% of total sector value. The heterogeneous impact suggests that press is subject to focalism, where the negative impact for the gas-majors is extrapolated to impact the entire energy sector. Critically, and despite the heterogeneous impacts, that the results show that regulatory changes are materially affecting the performance of the energy sector as a whole. The negative impact implies an increased cost of equity capital for energy utilities, negatively impacting their ability to raise the $2.2 trillion of total power sector investment is needed to transition to a ‘smart’ decarbonised energy system (IEA, 2014). A stable and sound market framework that reduces political uncertainty will encourage long-term investment in the energy sector (Cramton and Ockenfels, 2012). EU institutions should bear in mind that policy objectives may conflict and liberalisation is making it harder to achieve ambitious decarbonisation goals.

7.5 Thesis Limitations and Avenues for Further Research

Limitation of space and time dictated that some interesting avenues for further research related to the risk factors in European utilities returns could not be explored. The purpose of this section is to highlight these possible avenues for future research and related limitations.

One limitation of this thesis is the inability to delineate the sample by operation. Section 5.3.2.1 (Table 5.1) showed that the SIC system could, at best, delineate the sample based on industry. If possible, it would have been preferable to delineate the electricity and natural gas producers into generation/production, transmission and distribution operations. It is expected that the transmission companies (to the extent that they are independent of generation and distribution) a reregulated and therefore may be less susceptible to the impact of stock market risk factors, macroeconomic variables and regulatory changes. One possible method is to use a smaller sample and to identify operations via company annual reports. With this method, it may also be possible to further delineate the sample based on energy sources: renewable versus combustion fuel sources. This would contribute to understanding asset stranding as a result of renewable energy objectives and grid priority afforded to renewable energy generators, extending the work of Ansar et al. (2013). The expectation is that electric generators which are able to adapt should experience significantly positive CAARs as a result of growth opportunities from the renewable energy objectives.

The global and local AFFMs have been utilised in this thesis to examine inter-sectoral returns and within-sector heterogeneity. The focus on stock returns was to remain congruent with the majority of the literature outlined in Chapter 3, as shown in Table 3.1. A natural extension of the AFFM is to examine the cost of capital for European energy utilities. Koch and Bassen (2013) use an augmented-CAPM to examine cost of capital for electricity generators, however, Chapter 5 of this thesis showed that the local AFFM does a better job at capturing returns in the energy sector. Further, Section 1.5 highlighted that this thesis uses a superior energy sample. The method could extend Fama and French (1997), who examine industry cost of capital using CAPM and a global three-factor model, by utilising the local stock market risk factors developed in Chapter 5.

While the paragraph above focused on the dependent variable, the literature in Chapter 3 also highlights that additional independent variables have been identified, but examined to a lesser extent compared with stock market risk factors and commodities. The first avenue with regard to independent variables would be examining the impact of commodity volatility on energy sector returns. This would extend Elyasiani et al. (2011) who examine the impact of both oil returns and oil volatility on oil & gas sector returns. The rationale is that the Security of Supply stream is expected to affect oil and petroleum products, partially regulating prices and preventing abnormal price increases. This must undoubtedly affect return and volatility of oil and petroleum. Therefore, changing the volatility dynamics of the commodities may impact the energy sector returns. The examination of volatility also opens avenues to understand asymmetric responses to positive and negative commodity innovations on returns; such as those examined by Sadorsky (2001) and Ramos and Veiga (2011). Methodologically, this suggests the use of a range of model specifications, such as the ARCH, GARCH, the Spline GARCH for low-frequency volatility, the Quadratic GARCH (QGARCH) for modelling asymmetric effects of positive and negative shocks, or the Asymmetric Power GARCH (APARCH) for changing power terms and asymmetric impact. However, the importance of these empirical models should not be overstated. A major criticism, identified in Section 3.1, is that the AFFM is based on four stock market risk factors and a major criticism is that it is an empirical model that has limited theoretical foundation.

Regarding the impact of regulatory changes, the event study approach aggregates the legislation into four distinct restructuring streams. An implicit assumption is that the impacts of the regulatory changes are of similar importance.[73] An avenue for further research with

---

[73] Note, we do not believe this to be a major issue in this thesis. The robustness checks in Section 6.4.3.1 showed that removing, say, one Internal Energy Market piece of legislation did not result in substantive differences in results or inference.

respect to legislation is to examine the regulatory changes individually. An event-by-event analysis will allow greater insight into the particular impact of a single regulatory change. This would be of interest to a researcher who has a preference for an in-depth analysis of a particular regulatory stream or legislative act. While this thesis has examined the collective impact of the liberalisation stream, a researcher could, for example, independently examine the unique market reaction surrounding the only the third packages of liberalisation. Further, this specific analysis would allow the researcher to follow the individual legislative act the key stages of the legislative procedure.

The event study approach can be extended to examine 1) buy-side versus sell-side abnormal returns preceding a regulatory event, or 2) stock turnover preceding a regulatory event. The former would indicate price pressure, while the latter is a measure of liquidity. Examining the variables above will provide further insight into the behaviour of investors around regulatory changes; for example, do investors de-risk or speculate on outcome of an upcoming regulatory event? Such an analysis is now possible given the list of restructuring events and key stages compiled in this thesis (see Table 2.1)

When regulatory changes are published, inevitably some investors will receive the information before it rapidly diffuses across the entire market – known as information asymmetry. With such potentially large transfers of wealth, there is strong motivation for investors to access any information which may affect asset prices at the earliest available opportunity. Investors who receive information first (informed investors) can adopt economically advantageous positions at the expense of other investors (uninformed investors). Microstructure literature has documented that information asymmetry creates an adverse selection problem, where uninformed investors are continually disadvantaged when trading against informed investors (Wang, 1993). Adverse selection represents an undiversifiable risk for uninformed investors, which has been documented to affect risk premia (Wang, 1993; Easley et al., 2002; Easley and O'Hara, 2004), price volatility and cause illiquidity in stocks (Wang, 1993; Brennan and Subrahmanyam, 1996). Certainly, Chapter 6 (Section 6.4.2.1) showed that the market begins to react in the days prior to the announcement of positions. This avenue for future research would be grounded in the microstructure literature and would explore the effects of asymmetric information related to regulatory change using high frequency data (intraday) in the context of European energy utilities.

The four restructuring streams in Section 2.2 were designed to affect the operating environment (Internal Energy Market), energy consumption (Energy Efficiency), the use of green-energy technology (Renewable Energies) and securing energy at the EU level (Security of Supply). This thesis examines the impact of the four restructuring streams using market data. An implicit assumption of any financial analysis is that investors are rational, wealth optimizing and forward-looking, reassessing their investment portfolios today based on their *expected* future changes to the firm's operational and financial return. But does restructuring induce *realised* changes in the operational performance? Future research can examine the impact of the four restructuring streams on the operational performance and accounting-based financial ratios of energy utilities. This avenue of research can be multi-faceted, drawing on energy policy, finance, firm bankruptcy and accounting literatures. Such research could draw on related and established literature, including Megginson et al. (1994) and Hart and Ahuja (1996). Megginson et al. (1994) compare the pre- and post-privatisation financial and operating performance of 61 companies, across 18 countries and 32 industries, between 1961 and 1990. Hart and Ahuja (1996) examine the effect of emission reduction objectives on the accounting performance of 127 manufacturing, mining, and production firms between 1989 and 1992.

An analysis of accounting performance would have relevance to both internal controls and external evaluation of energy utilities. The analysis of financial ratios would examine the impact of regulatory changes on realised profitability at firm-level. Further, Altman (1968) suggests that an analysis of financial ratios could be used by the utilities as an internal control which allows managers to identify strengths and weaknesses of their firm prior to distress and firm failure. Various financial ratios related to firm liquidity, leverage, profitability or cash flows would provide an indication of firm distress as a result of regulatory changes.

◆

REFERENCES

ACER 2013. Annual report on the results of monitoring the internal electricity and natural gas markets in 2012. Brussels: Agency for the Cooperation of Energy Regulators.

Agrawal, J. & Kamakura, W. A. 1995. The economic worth of celebrity endorsers: An event study analysis. *Journal of Marketing,* 59**,** 56-62.

Ahlstrom, M., Ela, E., Riesz, J., Sullivan, J. O., Hobbs, B. F., Malley, M. O., Milligan, M., Sotkiewicz, P. & Caldwell, J. 2015. The Evolution of the Market: Designing a Market for High Levels of Variable Generation. *IEEE Power and Energy Magazine,* 13**,** 60-66.

Alford, A. W., Jones, J. J. & Zmijewski, M. E. 1994. Extensions and violations of the statutory SEC form 10-K filing requirements. *Journal of Accounting and Economics,* 17**,** 229-254.

Alogoskoufis, G. S. & Smith, R. 1991. The Phillips Curve, the persistence of inflation, and the Lucas critique: evidence from exchange-rate regimes. *The American Economic Review,* 81**,** 1254-1275.

Andrews, D. W. K. 1993. Tests for parameter instability and structural change with unknown change point. *Econometrica,* 61**,** 821-856.

Andrews, D. W. K., Lee, I. & Ploberger, W. 1996. Optimal changepoint tests for normal linear regression. *Journal of Econometrics,* 70**,** 9-38.

Ansar, A., Caldecott, B. & Tilbury, J. 2013. Stranded assets and the fossil fuel divestment campaign: what does divestment mean for the valuation of fossil fuel assets. *Stranded Assets Programme, SSEE, University of Oxford*.

Arouri, M. E. H. 2011. Does crude oil move stock markets in Europe? A sector investigation. *Economic Modelling,* 28**,** 1716-1725.

Bai, J. & Perron, P. 1998. Estimating and testing linear models with multiple structural changes. *Econometrica,* 66**,** 47-78.

Bai, J. & Perron, P. 2003. Computation and analysis of multiple structural change models. *Journal of Applied Econometrics,* 18**,** 1-22.

Banz, R. W. 1981. The relationship between return and market value of common stocks. *Journal of Financial Economics,* 9**,** 3-18.

Basher, S. A., Haug, A. A. & Sadorsky, P. 2012. Oil prices, exchange rates and emerging stock markets. *Energy Economics,* 34**,** 227-240.

Basher, S. A. & Sadorsky, P. 2006. Oil price risk and emerging stock markets. *Global Finance Journal,* 17**,** 224-251.

Beaver, W. H. 1968. The information content of annual earnings announcements. *Journal of Accounting Research***,** 67-92.

Bellman, R. & Roth, R. 1969. Curve fitting by segmented straight lines. *Journal of the American Statistical Association,* 64**,** 1079-1084.

Beneish, M. D. 1991. The effect of regulatory changes in the airline industry on shareholders' wealth. *Journal of Law and Economics,* 34**,** 395-430.

Berger, A. N. & Humphrey, D. B. 1997. Efficiency of financial institutions: International survey and directions for future research. *European Journal of Operational Research,* 98**,** 175-212.

Bernard, V. L. 1987. Cross-sectional dependence and problems in inference in market-based accounting research. *Journal of Accounting Research,* 25**,** 1-48.

Binder, J. J. 1985. Measuring the effects of regulation with stock price data. *The RAND Journal of Economics,* 16**,** 167-183.

Boehmer, E., Masumeci, J. & Poulsen, A. B. 1991. Event-study methodology under conditions of event-induced variance. *Journal of Financial Economics,* 30**,** 253-272.

Boni, L. & Womack, K. L. 2006. Analysts, industries, and price momentum. *Journal of Financial and Quantitative Analysis,* 41**,** 85-109.

Boyer, M. M. & Filion, D. 2007. Common and fundamental factors in stock returns of Canadian oil and gas companies. *Energy Economics,* 29**,** 428-453.

Bragdon, J. H. & Marlin, J. 1972. ls pollution profitable? *Risk Management,* 19**,** 9-18.

Brandt, M. W., Brav, A., Graham, J. R. & Kumar, A. 2009. The idiosyncratic volatility puzzle: time trend or speculative episodes? *Review of Financial Studies*.

Brown, S. J. & Warner, J. B. 1980. Measuring security price performance. *Journal of Financial Economics,* 8**,** 205-258.

Caldecott, B. & McDaniels, J. 2014. Stranded generation assets: Implications for European capacity mechanisms, energy markets and climate policy. Working Paper. Smith School of Enterprise and the Environment, University of Oxford (Oxford, UK).

Caldecott, B. & Robins, N. 2014. Greening China's financial markets: The isks and opportunities of stranded assets. Smith School of Enterprise and the Environment Breifing Paper.

Campbell, C. J. & Wesley, C. E. 1993. Measuring security price performance using daily NASDAQ returns. *Journal of Financial Economics,* 33**,** 73-92.

Carhart, M. M. 1997. On persistence in mutual fund performance. *The Journal of Finance,* 52**,** 57-82.

Carney, M. 2014. *RE: Letter from Mark Carney on Stranded Assets.* Type to JOAN WALLEY MP.

Chan, K. C. & Chen, N. F. 1991. Structural and return characteristics of small and large firms. *The Journal of Finance,* 46**,** 1467-1484.

Chan, K. C., Chen, N. F. & Hsieh, D. A. 1985. An exploratory investigation of the firm size effect. *Journal of Financial Economics,* 14**,** 451-471.

Chan, L. K. C., Hamao, Y. & Lakonishok, J. 1991. Fundamentals and stock returns in Japan. *The Journal of Finance,* 46**,** 1739-1764.

Chen, N. F., Roll, R. & Ross, S. A. 1986. Economic forces and the stock market. *The Journal of Business,* 59**,** 383-403.

Chen, S. S. & Chen, H. C. 2007. Oil prices and real exchange rates. *Energy Economics,* 29**,** 390-404.

Chow, G. C. 1960. Tests of equality between sets of coefficients in two linear regressions. *Econometrica,* 28**,** 591-605.

Cludius, J., Hermann, H., Matthes, F. C. & Graichen, V. 2014. The merit order effect of wind and photovoltaic electricity generation in Germany 2008–2016: Estimation and distributional implications. *Energy Economics,* 44**,** 302-313.

Conover, C. M., Miller, R. E. & Szakmary, A. 2008. The timeliness of accounting disclosures in international security markets. *International Review of Financial Analysis,* 17**,** 849-869.

Corsatea, T. D., Giaccaria, S., Covrig, C.-F., Zaccarelli, N. & Ardelean, M. 2016. RES diffusion and R&D investments in the flexibilisation of the European electricity networks. *Renewable and Sustainable Energy Reviews,* 55**,** 1069-1082.

Costantini, V., Gracceva, F., Markandya, A. & Vicini, G. 2007. Security of energy supply: Comparing scenarios from a European perspective. *Energy Policy,* 35**,** 210-226.

Cowan, A. R. & Sergeant, A. M. 1996. Trading frequency and event study test specification. *Journal of Banking & Finance,* 20**,** 1731-1757.

Cramton, P. & Ockenfels, A. 2012. Economics and design of capacity markets for the power sector. *Zeitschrift für Energiewirtschaft,* 36**,** 113-134.

Cunado, J. & Perez de Gracia, F. 2014. Oil price shocks and stock market returns: Evidence for some European countries. *Energy Economics,* 42**,** 365-377.

Daniel, K., Hirshleifer, D. & Subrahmanyam, A. 1998. Investor psychology and security market under- and overreactions. *The Journal of Finance,* 53**,** 1839-1885.

De Bondt, W. F. M. & Thaler, R. 1985. Does the stock market overreact? *The Journal of Finance,* 40**,** 793-805.

DECC 2010. Electricity Market Reform: Consultation document. London: Department of Energy & Climate Change.

DECC 2013. Future management of the compulsory stocking obligation in the UK. London: Department of Energy & Climate Change.

Delarue, E., Meeus, L., Belmans, R., D'haeseleer, W. & Glachant, J. M. 2011. Decarbonizing the European electric power sector by 2050: A tale of three studies. *EUI Working Papers***,** 1-14.

Delarue, E., Voorspools, K. & D’haeseleer, W. 2008. Fuel switching in the electricity sector under the EU ETS: Review and prospective. *Journal of Energy Engineering,* 134**,** 40-46.

Dellavigna, S. & Pollet, J. M. 2009. Investor inattention and Friday earnings announcements. *The Journal of Finance,* 64**,** 709-749.

Delmas, M. & Tokat, Y. 2005. Deregulation, governance structures, and efficiency: the U.S. electric utility sector. *Strategic Management Journal,* 26**,** 441-460.

Demers, E. & Vega, C. 2008. Soft information in earnings announcements: News or noise? *INSEAD Working Paper Series*.

Diaz-Rainey, I., Siems, M. & Ashton, J. K. 2011. The financial regulation of energy and environmental markets. *Journal of Financial Regulation and Compliance,* 19**,** 355-369.

Dickey, D. A. & Fuller, W. A. 1979. Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American Statistical Association,* 74**,** 427-431.

Dimson, E. 1979. Risk measurement when shares are subject to infrequent trading. *Journal of Financial Economics,* 7**,** 197-226.

Dobes, L., Jotzo, F. & Stern, D. I. 2014. The economics of global climate change: A historical literature review. *Review of Economics,* 65**,** 281-320.

Dorian, J. P., Franssen, H. T. & Simbeck, D. R. 2006. Global challenges in energy. *Energy Policy,* 34**,** 1984-1991.

Drax Group plc. 2015. *Biomass* [Online]. Available: http://www.drax.com/biomass/ [Accessed 30 July 2015].

Dyck, A. & Zingales, L. 2003. The media and asset prices. Working Paper, Harvard Business School.

Dyckman, T. R. & Smith, A. J. 1979. Financial accounting and reporting by oil and gas producing companies: A study of information effects. *Journal of Accounting and Economics,* 1**,** 45-75.

Edenhofer, O., Pichs-Madruga, R., Sokona, Y. & Seyboth, K. 2011. IPCC special report on renewable energy sources and climate change mitigation: Summary for policymakers. Cambridge.

EDF 2009. EDF Group 2009 Financial Report.

EDP 2009. Annual Report 2009.

Eikeland, P. O. 2011. The third internal energy market package: New power relations among Member States, EU institutions and non-state actors? *JCMS: Journal of Common Market Studies,* 49**,** 243-263.

El-Sharif, I., Brown, D., Burton, B., Nixon, B. & Russell, A. 2005. Evidence on the nature and extent of the relationship between oil prices and equity values in the UK. *Energy Economics,* 27**,** 819-830.

Elkington, J., Zeitz, J. & Branson, R. 2014. *The Breakthrough Challenge: 10 Ways to Connect Today's Profits With Tomorrow's Bottom Line*, Wiley.

Elyasiani, E., Mansur, I. & Odusami, B. 2011. Oil price shocks and industry stock returns. *Energy Economics,* 33**,** 966-974.

Energinet 2015. Market Model 2.0: Final report. Fredericia: Energinet.

Engelberg, J. Costly information processing: Evidence from earnings announcements. AFA 2009 San Francisco Meetings Paper, 2008.

Erdogdu, E. 2014. The political economy of electricity market liberalization: a cross-country approach. *The Energy Journal,* 35**,** 91-128.

European Commission. 2009. Analysis and statistics of the 2004-2009 legislature. Available: http://ec.europa.eu/codecision/statistics/docs/report_statistics_public_draft_en.pdf [Accessed 19 July 2015].

European Commission. 2015. *Ordinary Legislative Procedure "Step by Step"* [Online]. Available: http://ec.europa.eu/codecision/stepbystep/text/index5_en.htm [Accessed 19 July 2015].

European Parliament 2012. Drafting European Union Legislation. *Policy Department: Citizen's Rights and Constitutional Affairs,* (PE 462.442)**,** 1-33.

European Parliament. 2015. *Legislative Procedure* [Online]. Available: http://www.europarl.europa.eu/external/html/legislativeprocedure/default_en.htm [Accessed 31 July 2015].

European Parliament, Council & Commission 2007. Joint Declaration on Practical Arrangements for the Co-Decision Procedure (article 251 of the EC Treaty). *Official Journal of the European Union,* (2007/C 145/02)**,** 1-5.

Event Study Metrics. 2015. *Event Study Methodology* [Online]. Available: http://eventstudymetrics.com/index.php/event-study-methodology/ [Accessed 05 06 2015].

Faff, R. W. & Brailsford, T. J. 1999. Oil price risk and the Australian stock market. *Journal of Energy Finance & Development,* 4**,** 69-87.

Fama, E. F. & French, K. R. 1992. The cross-section of expected stock returns. *the Journal of Finance,* 47**,** 427-465.

Fama, E. F. & French, K. R. 1993. Common risk factors in the returns on stocks and bonds. *Journal of financial economics,* 33**,** 3-56.

Fama, E. F. & French, K. R. 1995. Size and book-to-market factors in earnings and returns. *The Journal of Finance,* 50**,** 131-155.

Fama, E. F. & French, K. R. 1996. Multifactor Explanations of Asset Pricing Anomalies. *The Journal of Finance,* 51**,** 55-84.

Fama, E. F. & French, K. R. 1997. Industry costs of equity. *Journal of Financial Economics,* 43**,** 153-193.

Fama, E. F. & French, K. R. 1998. Value versus growth: The international evidence. *The Journal of Finance,* 53**,** 1975-1999.

Fama, E. F. & French, K. R. 2006. The value premium and the CAPM. *The Journal of Finance,* 61**,** 2163-2185.

Fama, E. F. & French, K. R. 2012. Size, value, and momentum in international stock returns. *Journal of Financial Economics,* 105**,** 457-472.

Fanone, E., Gamba, A. & Prokopczuk, M. 2013. The case of negative day-ahead electricity prices. *Energy Economics,* 35**,** 22-34.

Filbeck, G. & Gorman, R. F. 2004. The relationship between the environmental and financial performance of public utilities. *Environmental and Resource Economics,* 29**,** 137-157.

Fisher, W. D. 1958. On Grouping for Maximum Homogeneity. *Journal of the American Statistical Association,* 53**,** 789-798.

Foster, G. 1980. Accounting policy decisions and capital market research. *Journal of Accounting and Economics,* 2**,** 29-62.

French, K. R. 2015. *Data Library* [Online]. Available: http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html [Accessed 02 May 2015].

Friends of the Earth 2014. The big six on the run: How renewables are disrupting big energy firms everywhere. London: Friends of the Earth.

FSR Energy. 2015. *Borchardt at DG Energy, EC on market design and network codes | Energy Today with JM Glachant* [Online]. Available:

https://soundcloud.com/fsregulation-energy-and-climate/klaus-dieter-borchardt-energy-today [Accessed 01 April 2015].

FTI-CL Energy 2015. Towards the target model 2.0: Policy recommendations for a sustainable EU power market design. Paris: FTI-CL Energy.

Garcia, R. & Perron, P. 1996. An analysis of the real interest rate under regime shifts. *The Review of Economics and Statistics,* 78**,** 111-125.

Gollop, F. M. & Roberts, M. J. 1983. Environmental regulations and productivity growth: The case of fossil-fueled electric power generation. *Journal of Political Economy,* 91**,** 654-674.

Gray, M. 2015. Coal: Caught in the EU utility death spiral. *Carbon Tracker Initiative* [Online]. Available: http://www.carbontracker.org/wp-content/uploads/2015/06/CTI-EU-Utilities-Report-v6-080615.pdf.

Green, R. 2006. Electricity liberalisation in Europe—how competitive will it be? *Energy Policy,* 34**,** 2532-2541.

Green, R. & Vasilakos, N. 2010. Market behaviour with large amounts of intermittent generation. *Energy Policy,* 38**,** 3211-3220.

Green, R. J. & Newbery, D. M. 1992. Competition in the British Electricity Spot Market. *Journal of Political Economy,* 100**,** 929-953.

Griffin, P., Jaffe, A. M., Lont, D. & Dominguez-Faus, R. 2015. Science and the stock market: Investors' recognition of unburnable carbon. *Energy Economics,* 52, Part A**,** 1-12.

Gual, J. 1999. Deregulation, integration, and market structure in European banking. *Journal of the Japanese and International Economies,* 13**,** 372-396.

Guthery, S. B. 1974. Partition regression. *Journal of the American Statistical Association,* 69**,** 945-947.

Hajizadeh, E., Seifi, A., Fazel Zarandi, M. H. & Turksen, I. B. 2012. A hybrid modeling approach for forecasting the volatility of S&P 500 index return. *Expert Systems with Applications,* 39**,** 431-436.

Hansen, B. E. 2001. The new econometrics of structural change: Dating breaks in U.S. labor productivity. *The Journal of Economic Perspectives,* 15**,** 117-128.

Harris, T. S. & Ohlson, J. A. 1987. Accounting disclosures and the market's valuation of oil and gas properties. *The Accounting Review,* 62**,** 651-670.

Hart, S. L. & Ahuja, G. 1996. Does it pay to be green? An empirical examination of the relationship between emission reduction and firm performance. *Business Strategy & the Environment,* 5**,** 30-37.

Haushalter, G. D. 2000. Financing policy, basis risk, and corporate hedging: Evidence from oil and gas producers. *The Journal of Finance,* 55**,** 107-152.

Heffron, R. J. & Nuttall, W. J. 2014. Scotland, nuclear energy policy and independence. *Energy Policy Research Group Working Paper***,** 1-20.

Hildmann, M., Ulbig, A. & Andersson, G. Revisiting the merit-order effect of renewable energy sources. Power & Energy Society General Meeting, 2015 IEEE, 26-30 July 2015 2015. 1-1.

Hirshleifer, D. 2001. Investor psychology and asset pricing. *The Journal of Finance,* 56**,** 1533-1597.

Hogan, W. W. 2005. On an "energy only" electricity market design for resource adequacy. *Working paper*.

Huang, R. D., Masulis, R. W. & Stoll, H. R. 1996. Energy shocks and financial markets. *Journal of Futures Markets,* 16**,** 1-27.

IEA 2006. Economics of retrofit air pollution control technologies. London: International Energy Agency Coal Research.

IEA 2009. The impact of the financial and economic crisis on global energy investment. Paris: IEA/OECD.

IEA 2012. Electricity information 2012. *International Energy Agency.* Paris: OECD.

IEA 2014. World energy investment outlook. Paris, France: IEA.
ITRE Committee 2014. The impact of the oil price on EU energy prices. Brussels: European Parliament.
Jamasb, T. & Pollitt, M. 2000. Benchmarking and regulation: International electricity experience. *Utilities Policy,* 9**,** 107-130.
Jamasb, T. & Pollitt, M. 2005. Electricity market reform in the European Union: Review of progress toward liberalization & integration. *The Energy Journal,* 26**,** 11-41.
Jegadeesh, N. & Titman, S. 1993. Returns to buying winners and selling losers: Implications for stock market efficiency. *The Journal of Finance,* 48**,** 65-91.
Jegadeesh, N. & Titman, S. 2001. Profitability of momentum strategies: An evaluation of alternative explanations. *The Journal of Finance,* 56**,** 699-720.
Jones, C. M. & Kaul, G. 1996. Oil and the stock markets. *The Journal of Finance,* 51**,** 463-491.
Joskow, P. 2013. Symposium on ‘Capacity Markets’. *Economics of Energy and Environmental Policy,* 2.
Joskow, P. L. 2008. Lessons learned from electricity market liberalization. *The Energy Journal,* 29**,** 9-42.
Kane, E. J. & Unal, H. 1988. Change in market assessments of deposit-institution riskiness. *Journal of Financial Services Research,* 1**,** 207-229.
Kanellakis, M., Martinopoulos, G. & Zachariadis, T. 2013. European energy policy—A review. *Energy Policy,* 62**,** 1020-1030.
Karpoff, J. M. & Lott, J. R., Jr. 1993. The reputational penalty firms bear from committing criminal fraud. *Journal of Law and Economics,* 36**,** 757-802.
Kaufmann, R. K. 2011. The role of market fundamentals and speculation in recent price changes for crude oil. *Energy Policy,* 39**,** 105-115.
Keim, D. B. 1983. Size-related anomalies and stock return seasonality: Further empirical evidence. *Journal of Financial Economics,* 12**,** 13-32.
Klassen, R. D. & McLaughlin, C. P. 1996. The impact of environmental management on firm performance. *Management Science,* 42**,** 1199-1214.
Koch, N. & Bassen, A. 2013. Valuing the carbon exposure of European utilities. The role of fuel mix, permit allocation and replacement investments. *Energy Economics,* 36**,** 431-443.
Konchitchki, Y. & O'Leary, D. E. 2011. Event study methodologies in information systems research. *International Journal of Accounting Information Systems,* 12**,** 99-115.
Kumar, A. 2009. Hard-to-value stocks, behavioral biases, and informed trading. *Journal of Financial and Quantitative Analysis,* 44**,** 1375-1401.
Kumbhakar, S. C., Lozano-Vivas, A., Lovell, C. A. K. & Hasan, I. 2001. The effects of feregulation on the performance of financial institutions: The case of Spanish savings banks. *Journal of Money, Credit and Banking,* 33**,** 101-120.
Lacalle, D. & Parrilla, D. 2015. *The Energy World is Flat: Opportunities from the End of Peak Oil,* Wiley.
Lettau, M., Ludvigson, S. C. & Wachter, J. A. 2008. The declining equity premium: What role does macroeconomic risk play? *Review of Financial Studies,* 21**,** 1653-1687.
Lintner, J. 1965. The valuation of risk assets and the selection of risky investments in stock portfolios and capital budgets. *The Review of Economics and Statistics***,** 13-37.
Lowry, M., Officer, M. S. & Schwert, G. W. 2010. The variability of IPO initial returns. *The Journal of Finance,* 65**,** 425-465.
Lundblad, C. 2007. The risk return tradeoff in the long run: 1836–2003. *Journal of Financial Economics,* 85**,** 123-150.
MacKinlay, A. C. 1997. Event studies in economics and finance. *Journal of Economic Literature,* 35**,** 13-39.

Manning, N. 1991. The UK oil industry: some inferences from the efficient market hypothesis. *Scottish Journal of Political Economy,* 38**,** 324-334.

Markowitz, H. 1952. Portfolio selection*. *The Journal of Finance,* 7**,** 77-91.

McKibben, B. 2012. Global warming's terrifying new math. *Rolling Stone,* 19**,** 43.

McKinsey & Company 2014. Beyond the storm – value growth in the EU power sector. *In:* VAHLENKAMP, T. & LEGER, S. (eds.).

McWilliams, A. & Siegel, D. 1997. Event Studies in Management Research: Theoretical and Empirical Issues. *The Academy of Management Journal,* 40**,** 626-657.

Megginson, W. L., Nash, R. C. & Randenborgh, M. V. 1994. The financial and operating performance of newly privatized firms: An international empirical analysis. *The Journal of Finance,* 49**,** 403-452.

Merton, R. C. 1973. An intertemporal capital asset pricing model. *Econometrica,* 41**,** 867-887.

Meznar, M. B., Nigh, D. & Kwok, C. C. Y. 1994. Effect of announcements of withdrawal from South Africa on stockholder wealth. *The Academy of Management Journal,* 37**,** 1633-1648.

Moskowitz, T. J. & Grinblatt, M. 1999. Do industries explain momentum? *The Journal of Finance,* 54**,** 1249-1290.

Nandha, M. & Faff, R. 2008. Does oil move equity prices? A global view. *Energy Economics,* 30**,** 986-997.

Narayan, P. K. & Gupta, R. 2015. Has oil price predicted stock returns for over a century? *Energy Economics,* 48**,** 18-23.

Narayan, P. K. & Smyth, R. 2008. Energy consumption and real GDP in G7 countries: New evidence from panel cointegration with structural breaks. *Energy Economics,* 30**,** 2331-2341.

Newbery, D. 2015. Missing money and missing markets: Reliability, capacity auctions and interconnectors. *Energy Policy*.

Newbery, D. M. 1998. Competition, Contracts, and Entry in the Electricity Spot Market. *The RAND Journal of Economics,* 29**,** 726-749.

Newbery, D. M. 2002. Problems of liberalising the electricity industry. *European Economic Review,* 46**,** 919-927.

Newbery, D. M. 2016. Towards a green energy economy? The EU Energy Union's transition to a low-carbon zero subsidy electricity system–Lessons from the UK's Electricity Market Reform. *Applied Energy*.

Newey, W. K. & West, K. D. 1987. A simple, positive semi-definite, heteroskedasticity and autocorrelation consistent covariance matrix. *Econometrica,* 55**,** 703-708.

Nwaeze, E. 2000. Deregulation of the electric power industry: The earnings, risk, and return effects. *Journal of Regulatory Economics,* 17**,** 49-67.

Oberndorfer, U. 2009a. Energy prices, volatility, and the stock market: Evidence from the Eurozone. *Energy Policy,* 37**,** 5787-5795.

Oberndorfer, U. 2009b. EU emission allowances and the stock market: Evidence from the electricity industry. *Ecological Economics,* 68**,** 1116-1126.

Osorio, S. & van Ackere, A. 2014. Security of supply in the Swiss electricity market: A system dynamics approach. *International System Dynamics Conference***,** 1-24.

Park, J. & Ratti, R. A. 2008. Oil price shocks and stock markets in the U.S. and 13 European countries. *Energy Economics,* 30**,** 2587-2608.

Patell, J. M. 1976. Corporate forecasts of earnings per share and stock price behavior: Empirical test. *Journal of Accounting Research,* 14**,** 246-276.

Patell, J. M. & Wolfson, M. A. 1979. Anticipated information releases reflected in call option prices. *Journal of Accounting and Economics,* 1**,** 117-140.

Pezzey, J. C. V. & Jotzo, F. 2012. Tax-versus-trading and efficient revenue recycling as issues for greenhouse gas abatement. *Journal of Environmental Economics and Management,* 64**,** 230-236.

Princeton University. 2008. *Event studies with Stata* [Online]. Available: http://dss.princeton.edu/online_help/analysis/eventstudy.html [Accessed 07 2015].

Quandt, R. E. 1960. Tests of the hypothesis that a linear regression system obeys two separate regimes. *Journal of the American Statistical Association,* 55**,** 324-330.

Quirin, J. J., Berry, K. T. & O'Bryan, D. 2000. A fundamental analysis approach to oil and gas firm valuation. *Journal of Business Finance & Accounting,* 27**,** 785-820.

Ramos, S. B. & Veiga, H. 2011. Risk factors in oil and gas industry returns: International evidence. *Energy Economics,* 33**,** 525-542.

Riesz, J. & Milligan, M. 2015. Designing electricity markets for a high penetration of variable renewables. *Wiley Interdisciplinary Reviews: Energy and Environment,* 4**,** 279-289.

Robinson, D. 2015. The scissors effect: How structural trends and government intervention are damaging major European electricity companies and affecting consumers. Oxford: Oxford Institute for Energy Studies.

Roll, R. 1977. A critique of the asset pricing theory's tests Part I: On past and potential testability of the theory. *Journal of financial economics,* 4**,** 129-176.

Rosenberg, B., Reid, K. & Lanstein, R. 1985. Persuasive evidence of market inefficiency. *The Journal of Portfolio Management,* 11**,** 9-16.

Sadorsky, P. 1999. Oil price shocks and stock market activity. *Energy Economics,* 21**,** 449-469.

Sadorsky, P. 2001. Risk factors in stock returns of Canadian oil and gas companies. *Energy Economics,* 23**,** 17-28.

Schipper, K. & Thompson, R. 1983. The impact of merger-related regulations on the shareholders of acquiring firms. *Journal of Accounting research***,** 184-221.

Scholtens, B. & Yurtsever, C. 2012. Oil price shocks and European industries. *Energy Economics,* 34**,** 1187-1195.

Schwert, G. W. 1981. Using financial data to measure effects of regulation. *Journal of Law and Economics***,** 121-158.

Sharpe, W. F. 1964. Capital asset prices: A theory of market equilibrium under conditions of risk*. *The Journal of Finance,* 19**,** 425-442.

Siliverstovs, B., L'Hégaret, G., Neumann, A. & von Hirschhausen, C. 2005. International market integration for natural gas? A cointegration analysis of prices in Europe, North America and Japan. *Energy Economics,* 27**,** 603-615.

Single European Act 1987. Treaties establishing the European Communities. *Office for Official Publications of the European Communities,* 1**,** 1-1128.

Söderholm, P. 1998. Fuel choice in West European power generation since the 1960s. *OPEC Review,* 22**,** 201-231.

Söderholm, P. 2001. Fossil fuel flexibility in west European power generation and the impact of system load factors. *Energy Economics,* 23**,** 77-97.

Solomon, D. H. 2012. Selective publicity and stock prices. *The Journal of Finance,* 67**,** 599-638.

Spedding, P., Mehta, K. & Robins, N. 2013. Oil & carbon revisited: Value at risk from ‘unburnable’ reserves. *HSBC Global Research,* 25.

Sussex Energy Group 2015. Response to Ofgem's discussion paper on 'Non-traditional business models: Supporting transformative change in the energy market.'. University of Sussex.

The BBC. 2013. *Labour energy freeze plan 'could bankrupt investors'* [Online]. Available: http://www.bbc.co.uk/news/business-25219453.

The Economist. 2010. Dr Evil or drivel? *The Economist*, 11 November, p.90.

The Economist. 2013a. Energy firms and climate change: Unburnable fuel. *The Economist*, 04 May.

The Economist. 2013b. How to lose half a trillion euros. *The Economist*, 12 October, p.27.

The Economist. 2013c. Tilting at windmills. *The Economist*, 19 June.

The Economist. 2015. *Puffs of hope* [Online]. Available: www.economist.com/news/leaders/21660124-wind-and-solar-energy-are-increasingly-competitive-lot-has-change-they-can-make [Accessed 03 August 2015].

Treaty of Rome. 1957. *Treaty establishing the European Economic Community* [Online]. Available: http://eur-lex.europa.eu/legal-content/EN/NOT/?uri=CELEX:11957E/TXT [Accessed 20 August 2015].

von der Fehr, N.-H. M., xf, rch & Harbord, D. 1993. Spot Market Competition in the UK Electricity Industry. *The Economic Journal*, 103**,** 531-546.

Wald, A. 1942. On the power function of the analysis of variance test. *The Annals of Mathematical Statistics*, 13**,** 434-439.

Walley, N. & Whitehead, B. 1994. It's not easy being green. *Harvard Business Review*, 72**,** 46-51.

Yang, M., Blyth, W., Bradley, R., Bunn, D., Clarke, C. & Wilson, T. 2008. Evaluating the power investment options with uncertainty in climate policy. *Energy Economics*, 30**,** 1933-1950.

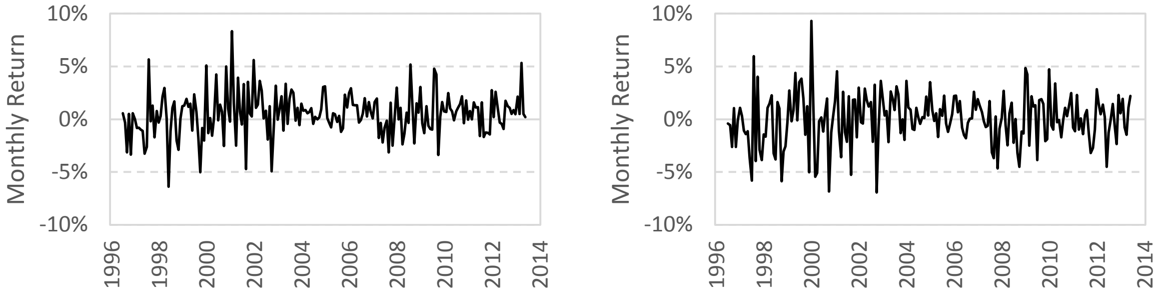
Appendix A. STOCK MARKET RISK FACTOR COMPARISON

As discussed in Section 4.2.4, French (2015) provides access to monthly data regarding the three additional stock market risk factors to implement the four-factor model, including: size, value and momentum premia. The purpose is to allow researchers to implement three- and four-factor models without the task of calculating the additional risk factors. This thesis requires the manual calculation of the three additional stock market risk factors on a daily basis to examine the time-varying nature of risk premia (Chapters 4 and5) and to implement the event study approach surrounding regulatory changes (Chapter 6). Following the methodologies of Fama and French (1992, 1993, 1995, 1996, 1997, 1998, 2006, 2012), Jegadeesh and Titman (1993) and Carhart (1997), the three additional stock market risk factors are calculated. Guidelines regarding adaptations for daily data are provided on French's (2015) website.

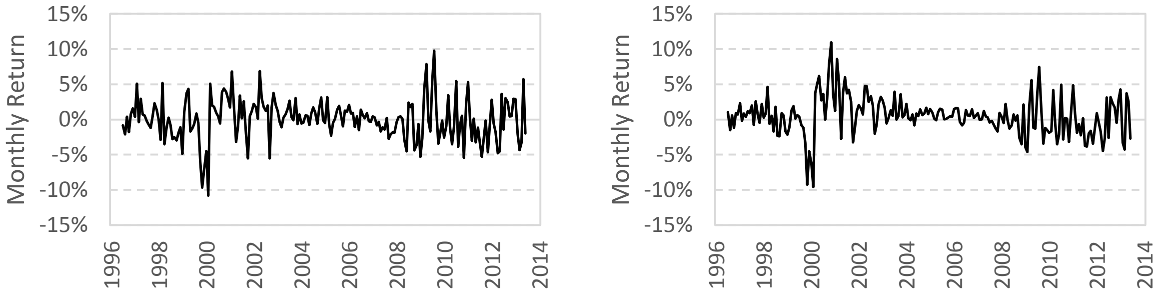
As the three premiums represent zero-investment portfolios, with both long- and short-positions, the cumulative returns of the investment strategy can be calculated. The cumulative returns on the three premiums are calculated as $cr_t = cr_{t-1} \times (1 + r_t)$, with cr_t forming a daily index through time. To convert the daily index to a monthly index, the values of cr_t are extracted on the last day of each month, between July 1996 and June 2013. The first-log difference of the monthly index is calculated to represent the percentage change each month. This is a simple method to compare the percentage change of the three premiums in the thesis against the percentage change of French's (2015) three premiums, on a monthly basis.

French (2015) uses a mean of 4,887 European companies, each month, to calculate the risk factors. No additional information regarding sample composition is provided. Due to data constraints, computational power and the discussion in Section 4.2.3, the thesis' sample is limited to the STOXX® 600 Europe index. However, the STOXX® 600 Europe index is designed to represent small, mid and large market capitalisations across a variety of sectors and therefore should be representative of European firms. *A priori*, some minor differences between the two return series may exist due to the methods of calculation and different sample sizes, but the general tenor of the results to be similar.

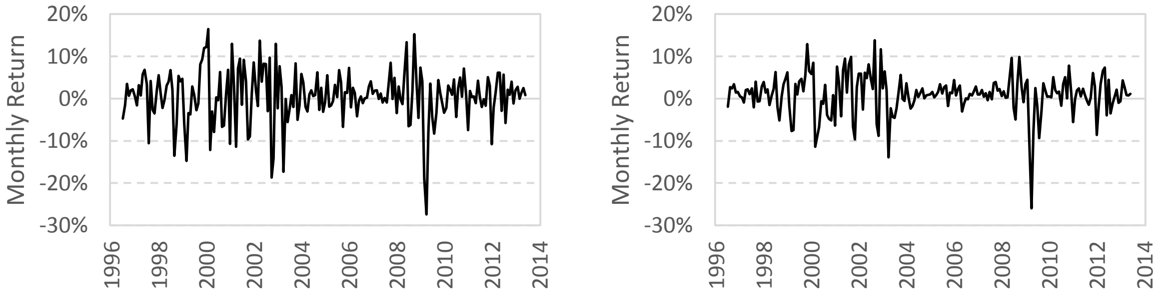
Figure A.1 presents the return series of the three stock market risk factors of this thesis compared with French's three factors. The thesis' factors (A1, B1 and C1) appear to have similar return profiles to French's (A2, B2 and C2), with relatively synchronised peaks and troughs throughout the time periods. Superficially, it appears that French's SMB factor (Plot A2) has greater magnitudes of changes than the thesis' SMB factor (Plot A1). This may be due to the differences in samples. French’s larger sample is likely to have a different composition of small and big firms, compared with the STOXX® 600 Europe Index. However, periods of volatility clustering occur in similar locations through time. The thesis’ HML factor (Plot B1) is relatively similar to French’s (Plot B2). French’s HML factor is more volatile in earlier years. The thesis’ UMD factor (Plot C1) shows greater volatility than French’s UMD factor (Plot C2) in the initial years.


(A1) Thesis SMB Factor

(A2) French SMB Factor


(B1) Thesis HML Factor

(B2) French HML Factor


(C1) Thesis UMD Factor

(C2) French UMD Factor

FIGURE A.1: COMPARISON OF THESIS’ THREE FACTORS AGAINST FRENCH’S THREE FACTORS

This figure illustrates the monthly returns on the three stock market risk factors (size, value and momentum premia) for the thesis and French (2015). The daily return for the thesis’ stock market risk factors is outlined in Section 4.2.4. The method of transformation to monthly data is provided in this thesis. French’s monthly stock market risk factors are extracted from French (2015).

Pairwise correlations between the three factors of the thesis and French were performed using monthly data between July 1996 and June 2013, with associated level of significance. The results are shown in Table A.1. The results of the pairwise correlations show strong correlation between the thesis' and French's three factors, with correlations of 0.602 for SMB, 0.810 for HML and 0.871 for UMD factors; all three correlations are significant at $p \leq 0.001$. Overall, the pairwise correlations are relatively consistent between the three factors. One difference between the two calculations appears to be the pairwise correlation between the SMB and HML factor. For French's SMB factor, the SMB-HML correlation was -0.126, $p \leq 0.1$. For the thesis' SMB factors, the SMB-HML correlation was 0.209, $p \leq 0.01$. However, the magnitude of the correlation coefficient still meets the condition of Fama and French (1993): the SMB and HML factors have low correlation and do not bias each other. Multicollinearity tests will be implemented on empirical analyses to ensure this proposition holds. The UMD-SMB and UMD-HML correlations have similar direction, magnitude and significance between the thesis' calculations and French's calculations.

TABLE A.1: PAIRWISE CORRELATIONS BETWEEN THE THESIS' AND FRENCH'S RISK FACTORS

This table shows the pairwise correlations between the three stock market risk factors of this thesis and those of French (2015). A ****, ***, ** or * denotes significance at 0.1%, 1%, 5% or 10%, respectively.

	${SMB_t}^{French}$	${HML_t}^{French}$	${UMD_t}^{French}$	SMB_t	HML_t	UMD_t
${SMB_t}^{French}$	1.000					
${HML_t}^{French}$	-0.126 *	1.000				
${UMD_t}^{French}$	0.110	-0.282 ****	1.000			
SMB_t	0.602 ****	0.250 ****	-0.020	1.000		
HML_t	-0.037	0.810 ****	-0.448 ****	0.209 ***	1.000	
UMD_t	0.136 *	-0.181 ***	0.871 ****	0.040	-0.355 ****	1.000

The overall conclusion is that the monthly returns of the three risk factors are relatively similar between this thesis and French (2015). The differences are likely due to the larger sample available to French, compared with fewer companies available in the thesis sample. The large positive correlations and strong significance between French's three factors and the thesis' three factors shows that the methods of calculating the risk factors can reasonably reproduce French's (2015) time series. The results of the thesis can be interpreted with greater confidence.

Appendix B.

DELINEATING THE SAMPLE ON SIZE AND BE/ME

B.1. The STOXX® 600 Europe firms

Using a similar method to Fama and French (1993), the 600 firms of the STOXX® 600 Europe index are sorted into a 5 × 5 matrix based on market capitalisation and (independently) on book-to-market ratios. Market capitalisations and BE/MEs at end of fiscal years are used for the sorting. The intersections of the matrix form 25 portfolios from the size and BE/ME quintiles. To examine the sorting method, the mean market capitalisation, book value of equity, BE/ME ratio and number of firms per intersection are calculated. The descriptive statistics are shown in Table B.1.

TABLE B.1: SIZE AND BOOK-TO-MARKET PORTFOLIOS FOR EUROPEAN STOCKS

Descriptive statistics for 25 portfolios formed on size and book-to-market quintiles. Portfolios are formed using annual data between 1996 and 2013. Market capitalisation and book value of equity is quoted in € billions. BE/ME ratios are calculated using firm size and book value of equity values within this table. Number of firms in portfolios includes firms where one or more observations, across all years, were identified as belonging to the portfolio.

Book-to-Market Equity (BE/ME) Quintiles

	PANEL A Average of Annual Averages of Market Cap. (€ Billion)					**PANEL B BE/ME Ratios**				
Size Quintile	**Low**	**2**	**3**	**4**	**High**	**Low**	**2**	**3**	**4**	**High**
Small	0.8	0.8	0.8	0.8	0.7	0.17	0.33	0.52	0.77	1.49
2	2.2	2.3	2.3	2.1	2.1	0.17	0.33	0.52	0.75	1.47
3	4.8	4.9	4.9	5.0	4.9	0.17	0.33	0.50	0.74	1.46
4	12.0	12.0	12.1	12.4	11.8	0.17	0.33	0.49	0.72	1.39
Big	72.4	66.9	62.4	63.2	49.1	0.16	0.33	0.50	0.73	1.31

	PANEL C Average of Annual Averages of Book Value of Equity (€ Billion)					**PANEL D Average of Annual Number of Firms in Portfolio**				
Size Quintile	**Low**	**2**	**3**	**4**	**High**	**Low**	**2**	**3**	**4**	**High**
Small	0.1	0.3	0.4	0.6	1.0	93	98	101	115	122
2	0.4	0.8	1.2	1.5	3.1	112	116	125	122	116
3	0.8	1.6	2.5	3.7	7.2	105	131	139	120	108
4	2.1	4.0	5.9	9.0	16.3	97	128	139	117	81
Big	11.6	22.3	31.4	46.2	64.4	78	93	104	90	57

Table B.1, Panel A shows that the sample can be reliably delineated on size. Each row for size is relatively uniform. The only exception include the largest firms, where big, low-BE/ME firms tend to be larger than big, high-BE/ME firms; also found by Fama and French (1993). Across the smallest size quintile, firm size ranges between €705.5 million and €847.0 million, while the largest size quintile captures firms between €49,117.2 million and €72,359.4 million. The sort on size should lead to reliable calculations of size premium.

Panel B shows that the BE/ME ratios are relatively uniform across columns, showing that the sample can be delineated by book-to-market ratio. Despite varying market capitalisations and book values of equity, a striking feature of is the uniform nature of the BE/ME ratios. The consistency across columns shows that the sort is largely free from the impact of size. The high-BE/ME quintile ranges from 1.31 to 1.49, while the low BE/ME quintile ranges between 0.16 and 0.17. These results mirror Fama and French (1993). The sort on BE/ME ratio should also lead to reliable calculations of value premium.

Although Fama and French (1993) do not report book value of equity portfolios, some interesting results can be observed in Panel C. While market capitalisation (Panel A) is relatively constant across size quintiles, Panel C shows that, across each row, the high BE/ME firms typically have larger book value of equity. This indicates the high-BE/ME quintile is capturing larger firms which have lost market value. In contrast, the low-BE/ME quintile captures smaller firms which are trading well above book-value. This would be consistent with firms which are perceived to be distressed.

Finally, Panel D shows that the majority of stocks are located in the middle quintiles, avoiding extreme size or BE/ME ratios.

B.2. The 88 European Energy Utilities

Following the method above (Section B.1), the 88 European utilities are sorted into a 5×5 matrix based on market capitalisation and (independently) on book-to-market ratios, forming 25 portfolios from the size and BE/ME quintiles. The results are shown in Table B.2.

The results in Table B.2 (Panel A) show that the energy sample can also be reliably delineated on size. The average firm size for the small quintile ranges between €130.3 million and €247.9 million,[74] while the big quintile ranges from €24,129.7 million to €43,220.9 million. Typically, the average market capitalisation for the 600 European stocks in Table B.1 tends to be larger than the 88 European energy utilities in Table B.2. Thus, the global size premium in Chapter 4 may have produced biased estimated SMB coefficients for the energy utility sector, as most energy utilities are of different size to most European firms. Despite the smaller mean sizes observed in Table B.2, the econometric results in Chapter 4 (Table 4.5) and Chapter 5 (Table 5.5) will show that big utilities dominate sector returns.

---

[74] Due to rounding, these values appear as 0.1 and 0.2 in Table B.2. The values are located in smallest size quintile of Panel A.

TABLE B.2: SIZE AND BOOK-TO-MARKET PORTFOLIOS FOR EUROPEAN ENERGY UTILITIES

Descriptive statistics for 25 portfolios for 88 European energy utilities formed on size and book-to-market quintiles. Portfolios are formed using annual data between 1996 and 2013. Market capitalisation and book value of equity are quoted in € billions. BE/ME ratios are calculated using firm size and book value of equity values within this table. Number of energy utilities in portfolios includes firms where one or more observations, across all years, were identified as belonging to the portfolio.

Book-to-Market Equity (BE/ME) quintiles

	PANEL A Average of Annual Average of Market Cap. (€ Billion)					**PANEL B BE/ME Ratio**				
Size Quintile	**Low**	**2**	**3**	**4**	**High**	**Low**	**2**	**3**	**4**	**High**
Small	0.1	0.2	0.2	0.2	0.1	0.28	0.46	0.68	0.77	1.80
2	2.1	0.9	1.3	1.3	1.0	0.28	0.44	0.53	0.81	1.67
3	3.9	5.3	5.4	3.8	2.6	0.33	0.44	0.63	0.76	1.15
4	11.7	11.3	9.4	6.1	3.0	0.25	0.43	0.63	0.77	1.07
Big	24.1	33.2	31.4	30.8	43.2	0.26	0.41	0.57	0.77	1.39

	PANEL C Average of Annual Average Book Value of Equity (€ Billion)					**PANEL D Number of Energy Utilities in Portfolio**				
Size Quintile	**Low**	**2**	**3**	**4**	**High**	**Low**	**2**	**3**	**4**	**High**
Small	0.0	0.1	0.2	0.1	0.2	6	9	6	9	13
2	0.6	0.4	0.7	1.0	1.7	10	15	14	16	18
3	1.3	2.3	3.4	2.9	3.0	15	13	19	15	11
4	2.9	4.8	5.9	4.7	3.2	15	16	20	17	6
Big	6.3	13.6	17.8	23.7	60.1	10	12	13	8	2

In nearly all cases, Panel B shows that the 88 European energy utilities in Table B.2 have higher average BE/ME ratios than the 600 European stocks (see Table B.1), indicating that energy utilities are perceived to be more distressed than most European stocks. The low-BE/ME (growth) firm's ratios range between 0.25 and 0.33, while the high-BE/ME (value) firm's ratios range between 1.07 and 1.80. The small, high-BE/ME energy utilities have highest BE/ME ratio of all energy utilities and all European stocks (see Table B.1). This indicates that these energy utilities are far more distressed than most European stocks. While the sample can reliably be delineated on BE/ME ratios, there is a peculiar observation within the highest-BE/ME quintile. Within the high-BE/ME quintile, the energy utilities[75] in size quintiles 3 and 4 have lower BE/ME ratios relative to other high-BE/ME elements. These BE/ME ratios are also lower than the equivalent European stock in the same elements (see Table B.1). The market must perceive some benefit for these companies, making them less risky in comparison with other energy utilities or European stocks. Many of these energy utilities represent some of the largest in Europe. The perceived benefit could be market dominance, a motivation for the liberalisation objectives (see Section 2.2.1).

---

[75] Quintile 3, high-BE/ME: Bewag, Cez, Fesca, Hyder, International Power, Lahmeyer, Public Power, Sydkraft, Union Fenosa, Vattenfall, and Verbund. Quintile 4, high-BE/ME: Bewag, Cez, Fortum, Sydkraft, Union Fenosa.

Regarding the book value of equity for European energy utilities (Panel C), the big and high-BE/ME element of the matrix has the greatest book-value of equity, while the small and low-BE/ME element have the lowest book-value of equity. The average book value of equity for energy utilities is typically smaller than the average book value of equity for European stocks (see Table B.1). Exceptions include the mid- to low-BE/ME stocks between the 2 to 4 size quintiles. These energy utilities tend to have a greater book value of equity than most European stocks. This may suggest that extremely big utilities are under particular pressure and investors shift their wealth from the largest to medium size energy utilities. The largest energy utilities become value firms, while medium size energy utilities become growth firms. This would certainly be consistent with the intended liberalisation and competition objectives in Section 2.2.1, negating the market dominance from the largest energy utilities. It may also explain why these energy utilities tend to have large book values of equity.

Concerning the distribution of energy utilities (Panel D), the results are similar to those observed in Table B.1. The number of energy utilities in each portfolio shows that most energy utilities are located in the middle quintiles for size and BE/ME ratios.

Appendix C.

COMPARISON OF RISK PREMIUMS WITH EXTANT LITERATURE

C.1. Comparison of Chapter 4 and Faff and Brailsford (1999)

Faff and Brailsford (1999) examine oil price risk across 24 Australian industries, using monthly data between July 1983 and March 1996. The coefficients are estimated using the following specification:

$$R_{it} = \alpha_i + b_i[R_{mt}] + o_i Oil_t + e_i \qquad \text{(A.1)}$$

Table C.1 compares the estimated coefficients from Faff and Brailsford (1999) to those obtained from the augmented-CAPM model (Equation 4.2) from Chapter 4 (See Table 4.5). For a simple comparison, the results only included oil coefficients - term structure and other commodity risk factors are omitted.

TABLE C.1: COMPARISON OF THESIS RESULTS TO FAFF AND BRAILSFORD (1999)

This table reports the estimated coefficients from the augmented-CAPM of Table 4.5, compared with the estimated coefficients of the two-factor model in Faff and Brailsford (1999).

	Thesis Coefficients		**Faff and Brailsford (1999)**	
	Market	**Oil**	**FB Market**	**FB Oil**
Banks	1.2385	-0.0115	0.7691	-0.0873
Oil & gas	0.9345	0.0719	0.9772	0.2349
Industrials	0.9872	0.0019	0.6892	0.0119
Insurance	1.2125	-0.0100	0.8821	0.0886
Retail	0.7792	-0.0177	0.8581	-0.0439
Media	0.9795	-0.0039	1.1810	-0.0850
Chemicals	0.9148	0.0009	0.8017	-0.0424
Financials	1.2206	-0.0090	0.7486	0.0526

Overall, the results are qualitatively similar. Typically, Faff and Brailsford's (1999) results show greater magnitude of oil price risk but lower magnitudes of systematic risk exposure. Of the oil price risk coefficients, three of the coefficients from this thesis are a different sign to Faff and Brailsford (1999). The differences in oil price risk may be due to Faff and Brailsford's (1999) calculation of oil returns, where oil is scaled by exchange rate. Moreover, the banking, financial and insurance sectors of the Australian market appear to have much lower market beta's compared with the equivalent European sectors. The differences in results are likely to be due to the fact that: 1) the two analyses are conducted over different time periods, 1983 to 1996 (Faff and Brailsford, 1999) versus 1996 to 2013 (this thesis), 2) different markets are analysed, the Australian and European markets, and 3) Faff and Brailsford (1999) examines stock returns, while this thesis examines excess stock returns. Regarding the former point, the time series in this thesis has been subject to the dot-com, GFC and EUC, which will affect estimated of systematic risk. Further, the purpose of the comparison is to examine whether estimated coefficients are in the same direction, rather than to replicate the model in its entirety.

C.2. Comparison of Chapter 4 and Fama and French (1997)

Table C.2 shows the results of Fama and French (1997), who examine risk loadings between the CAPM and three-factor asset pricing model. Fama and French (1997) implement the three-factor model on 48 industries, between July 1963 and December 1994, based on evidence that the CAPM is insufficient at explaining expected stock returns (Fama and French, 1992). Fama and French (1997) report substantial inter-sectoral variability in the relationship between the stock returns and additional risk factors: market returns, size premium and value premium. Fama and French (1997) estimate their coefficients using the standard CAPM and three-factor specifications:

$$R_i - R_F = \alpha_i + b_i[R_M - R_F] + e_i \tag{C.1}$$

$$R_i - R_F = \alpha_i + b_i[R_M - R_F] + s_i SMB + h_i HML + e_i \tag{C.2}$$

The coefficients for this thesis are based on the CAPM and four-factor specifications in Equations (4.1) and (4.3) of Chapter 4, omitting momentum from the reported coefficients (see Table 4.5). Table C.2 provides a summary of Fama and French's (1997) estimated coefficients, including sectors which are comparable to those investigated in Chapter 4.

TABLE C.2: SUMMARY OF FAMA AND FRENCH (1997) EMPIRICAL RESULTS

This table presents the estimated coefficients extracted from Fama and French (1997), using the CAPM and the three-factor model. Based on Fama and French's (1997) results, the mean and median coefficients are calculated.

	CAPM				Three-Factor Asset Pricing Model					
	a	$t(a)$	b	R^2	a	$t(a)$	b	s	h	R^2
Utilities	-0.00	-0.02	0.66	0.55	-0.17	-1.33	0.79	-0.20	0.38	0.62
Banks	-0.04	-0.26	1.09	0.76	-0.25	-1.84	1.13	0.13	0.35	0.79
Energy[A]	0.13	0.71	0.85	0.50	0.08	0.45	0.96	-0.35	0.21	0.54
Telecommunications	0.13	0.92	0.66	0.52	-0.02	-0.11	0.79	-0.23	0.35	0.59
Machinery[B]	-0.11	-0.86	1.16	0.82	-0.15	-1.22	1.11	0.25	-0.00	0.83
Insurance	0.08	0.39	1.01	0.58	0.03	0.14	1.00	0.09	0.06	0.58
Retail	0.07	0.48	1.11	0.73	0.06	0.37	1.04	0.27	-0.06	0.75
Computers[C]	-0.11	-0.55	1.04	0.59	0.13	0.66	0.90	0.17	-0.49	0.63
Fun[D]	0.21	0.91	1.35	0.64	0.08	0.40	1.17	0.83	-0.04	0.73
Chemicals	-0.02	-0.17	1.09	0.81	-0.10	-0.85	1.13	-0.03	0.17	0.81
Finance	0.19	1.14	1.16	0.72	0.12	0.75	1.11	0.30	0.02	0.74
Mean	**0.05**	**0.24**	**1.02**	**0.66**	**-0.02**	**-0.23**	**1.01**	**0.11**	**0.09**	**0.69**
Median	**0.07**	**0.39**	**1.09**	**0.64**	**0.03**	**0.14**	**1.04**	**0.13**	**0.06**	**0.73**

[A] Petroleum and natural gas companies, proxy for the oil & gas sector.

[B] Machinery companies, proxy for Industrials.

[C] Proxy for Technology sector.

[D] Defined as Entertainment firms, proxy for Media Sector.

Figure C.1 shows that the estimated market betas using the CAPM specification are similar between this thesis and those of Fama and French (1997). Estimated coefficients for the three-factor specifications are shown in Figure C.2. Of the 33 pairs of coefficients (market factor, SMB and HML across 11 sectors) in Figure C.2, all are in the same direction, except four pairs: SMB coefficients in the Insurance, Technology, and Chemicals sectors, and HML coefficients in the Telecommunications sector. The minor differences may be due to the influence of the momentum factor on estimated coefficients. Again, the time-period analysed could be a factor which affects the results: particularly as the thesis sample includes the dot-com collapse, GFC and EUC. Further, the comparison between the U.S. and Europe may produce different results. Qualitatively, the results are similar.

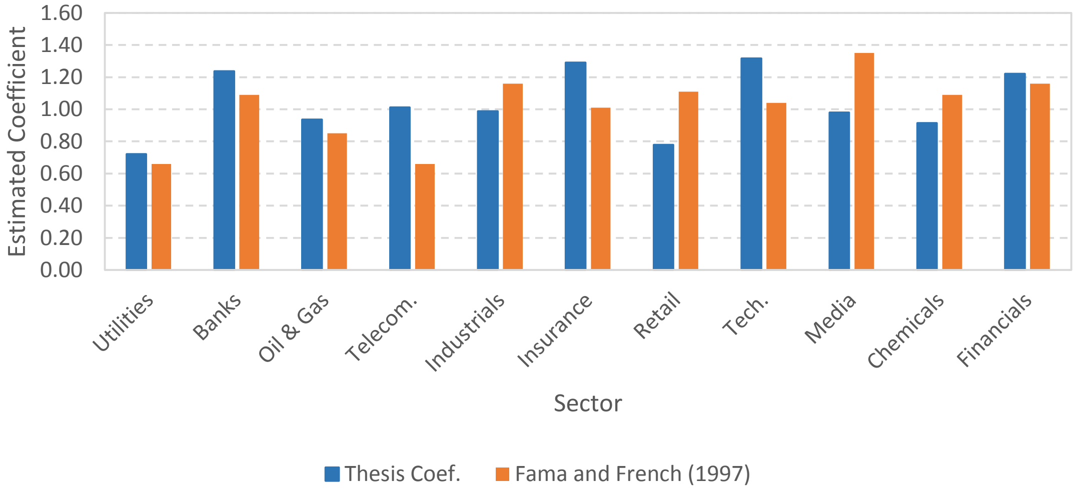


FIGURE C.1 COMPARISON OF MARKET BETA FROM CAPM SPECIFICATION

This figure reports the estimated coefficients for the CAPM specification of this thesis (Equation 4.1) and the CAPM specification of Fama and French (1997). The Market betas are compared across 11 sectors in the U.S. and Europe.

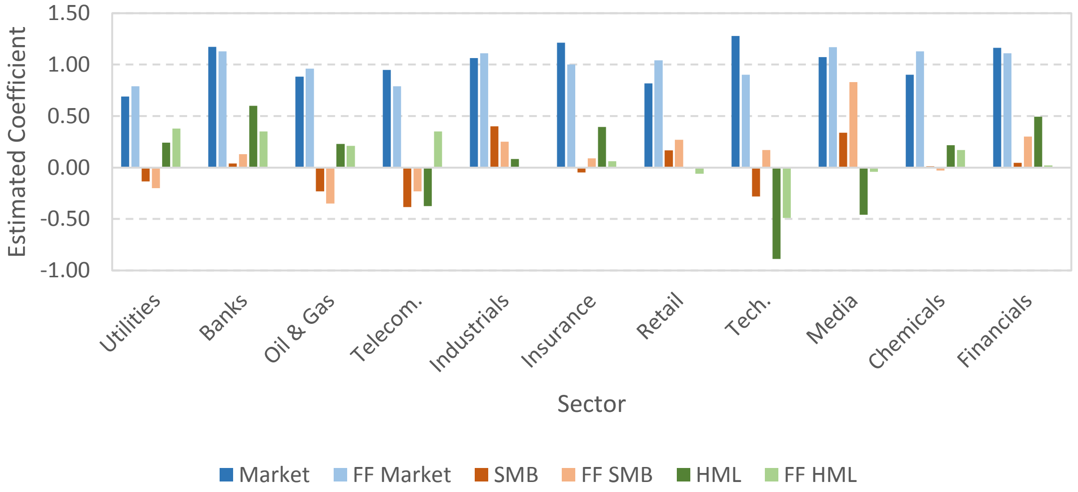


FIGURE C.2: COMPARISON OF ESTIMATED STOCK MARKET RISK FACTOR COEFFICIENTS

This figures illustrates a comparison of the estimated coefficients for the market factor, size premium and value premium. For the thesis, the estimated coefficients are extracted from the four-factor model in Equation (4.3). For Fama and French (1997), the estimated coefficients are extracted from a three-factor specification.

Appendix D. INTER-TEMPORAL ANALYSIS USING THE LOCAL AFFM

TABLE D.1: INTER-TEMPORAL ANALYSIS OF HIGH-BE/ME PORTFOLIO USING THE LOCAL AFFM

This table presents conditional annual local AFFM, estimated on a year-by-year basis using Newey-West HAC standard errors between 1996 and 2013. The value-weighted returns of the high-BE/ME portfolio ($\boldsymbol{R_{high}}$) is used as the dependent variable. The nine risk factors include: market premium ($\boldsymbol{R_m}$), local size premium ($LSMB$), local value premium ($LHML$), local momentum premium ($LUMD$), term premium ($\boldsymbol{R_{tp}}$), oil risk (R_o), coal risk (R_c), natural gas risk (R_g) and carbon risk (R_{co2}). The intercept and error term is denoted α_i and e, respectively. A ****, ***, ** or * denotes significance at 0.1%, 1%, 5% or 10%, respectively. The specification used is:

$$\boldsymbol{R_{high}} = \alpha_i + b_i\boldsymbol{R}_m + s_iLSMB + h_iLHML + m_iLUMD + tp_i\boldsymbol{R}_{tp} + o_iR_o + c_iR_{co} + g_iR_g + co2_iR_{co2} + e$$

Year	α_i	b_i	s_i	h_i	m_i	tp_i	o_i	c_i	g_i	$co2_i$	$\boldsymbol{adj.R^2}$	$\boldsymbol{F =}$	***Sig.***
1996[A]	-0.0002	0.3681 ****	-0.2631 ***	0.7317 ****	-0.0127	0.4066 *	0.0089	0.0117	-0.0120		80.89%	70.31	****
1997	0.0002	0.2161 ****	-0.4654 ****	0.7378 ****	-0.0238	-0.1120	0.0016	-0.0008	0.0072		82.54%	154.63	****
1998	0.0008	0.2681 ****	-0.2964 **	0.5440 ****	-0.0234	0.1909	0.0185	-0.0156	0.0047		69.98%	76.78	****
1999	0.0000	0.1016 **	-0.6668 ****	0.7197 ****	-0.0408	0.2137	0.0064	-0.0147	-0.0057		76.75%	108.31	****
2000	0.0004	0.1851 ****	-0.3232 ****	0.5297 ****	-0.0725	-0.4550	0.0088	0.0520	-0.0222 **		51.88%	35.91	****
2001	-0.0001	0.1488 ****	-0.4695 ****	0.5616 ****	0.0020	-0.0648	0.0080	0.0693 **	0.0124		65.97%	64.00	****
2002	-0.0008	0.1807 **	-0.3965 ****	0.9268 ****	-0.0099	0.1223	-0.0399	-0.0101	-0.0004		60.11%	49.96	****
2003	0.0007 **	0.2605 ****	-0.4327 ****	0.4325 ****	0.0696	-0.2412	0.0126	0.0347	0.0005		62.85%	55.97	****
2004	0.0009 ****	0.4421 ****	-0.2530 ****	0.7276 ****	0.0840 **	-0.5148	0.0075	0.0048	0.0065		78.60%	120.83	****
2005	0.0010 *	0.6787 ****	0.0501	0.4864 ****	0.3367 ****	0.5430	-0.0224	0.0113	0.0018		59.75%	49.07	****
2006	0.0001	0.8290 ****	0.1261 **	0.6382 ****	0.0632	-0.2386	0.0688 **	-0.0037	0.0027	0.0043	72.76%	77.86	****
2007	0.0007	0.5935 ****	-0.5873 ****	0.5255 ****	0.0205	-0.5805	0.1134 **	0.0161	0.0028	0.0009	55.17%	36.55	****
2008	0.0002	0.5810 ****	-0.0936	0.4209 ****	-0.0097	0.5546	0.0504	-0.0528 *	0.0320 *	0.0038	44.39%	24.15	****
2009	-0.0004	0.5346 ****	-0.2353 **	0.8176 ****	-0.0596	0.1503	0.0482 *	0.0480	-0.0042	0.0127	67.39%	60.69	****
2010	-0.0070	0.4484 ****	-0.7374 ****	0.8315 ****	-0.0435	4.1064	-0.0036	-0.0210	-0.0054	-0.0435 *	88.75%	228.83	****
2011	-0.0034	0.8108 ****	-0.5122 ****	0.5291 ****	0.0051	1.6816	0.0046	-0.0297	0.0211	0.0021	78.21%	104.27	****
2012	-0.0010	0.5711 ****	-0.4903 ****	0.9014 ****	-0.2079 ***	0.6378	0.0008	0.0209	-0.0446	-0.0044	76.09%	92.93	****
2013 [A]	-0.0017	0.6866 ****	-0.5873 ****	0.6346 ****	-0.1445	0.8197	-0.0173	-0.1093	0.0294	0.0019	74.39%	42.31	****
Mean:	-0.0005	0.4392	-0.3685	0.6498	-0.0037	0.4011	0.0153	0.0006	0.0015	-0.0028	69.25%		

[A] Due to rebalancing in June, data contains six months of observations.

Table D.2: Inter-Temporal Analysis of Mid-BE/ME Portfolio using the Local AFFM

This table presents conditional annual local AFFM, estimated on a year-by-year basis using Newey-West HAC standard errors between 1996 and 2013. The value-weighted returns of the mid-BE/ME portfolio ($\boldsymbol{R_{mid}}$) is used as the dependent variable. The nine risk factors include: market premium ($\boldsymbol{R_m}$), local size premium ($LSMB$), local value premium ($LHML$), local momentum premium ($LUMD$), term premium ($\boldsymbol{R_{tp}}$), oil risk (R_o), coal risk (R_c), natural gas risk (R_g) and carbon risk (R_{co2}). The intercept and error term is denoted α_i and e, respectively. A ****, ***, ** or * denotes significance at 0.1%, 1%, 5% or 10%, respectively. The specification used is:

$$\boldsymbol{R_{mid}} = \alpha_i + b_i\boldsymbol{R}_m + s_iLSMB + h_iLHML + m_iLUMD + tp_i\boldsymbol{R}_{tp} + o_iR_o + c_iR_{co} + g_iR_g + co2_iR_{co2} + \ e$$

Year	α_i		b_i		s_i		h_i		m_i		tp_i	o_i		c_i		g_i	$co2_i$		$\boldsymbol{adj.R^2}$	$\boldsymbol{F =}$	***Sig.***
1996^A	0.0001		0.5754	****	-0.4441	****	0.0160		0.1456	*	0.3583	-0.0298		-0.0503		-0.0074			62.93%	28.80	****
1997	0.0002		0.6361	****	-0.3002	****	0.0222		0.1975	****	-0.3451	0.0089		0.0044		0.0104			75.52%	101.27	****
1998	0.0002		0.5804	****	-0.3469	****	0.0437		-0.0322		0.0102	0.0013		-0.1241	****	0.0009			72.36%	86.07	****
1999	-0.0004		0.3346	****	-0.6570	****	0.1480	****	0.0619		-0.0336	0.0071		0.0480	***	0.0060			68.53%	71.78	****
2000	0.0005		0.1647	****	-0.5153	****	0.0807		-0.0458		-0.1371	-0.0072		0.0137		0.0001			32.15%	16.34	****
2001	0.0004		0.4133	****	-0.4306	****	-0.1016		0.0226		0.1432	0.0245		-0.0241		0.0039			56.99%	44.07	****
2002	0.0002		0.6181	****	-0.3121	****	-0.0042		-0.0521		-0.0224	-0.0222		-0.0223		0.0016			80.01%	131.08	****
2003	0.0003		0.5323	****	-0.3896	****	-0.1617	****	-0.0889		0.2923	-0.0125		-0.1014	***	0.0018			79.41%	126.34	****
2004	0.0008	**	0.5416	****	-0.2098	****	-0.0622	*	0.0736		0.0844	0.0037		-0.0476	*	0.0032			54.90%	40.71	****
2005	0.0001		0.7884	****	-0.1676	****	-0.0791	*	-0.0073		-0.1858	-0.0146		-0.0149		0.0015			50.77%	34.39	****
2006	0.0005		0.7980	****	-0.1699	****	-0.0715		0.1564	**	0.2175	0.0677	***	-0.0153		-0.0029	0.0192	****	59.56%	43.38	****
2007	0.0005		0.6990	****	-0.1754	****	-0.0832	**	-0.0234		-0.5763	0.0438	**	-0.0103		-0.0056	0.0002		70.59%	70.35	****
2008	0.0003		0.7408	****	-0.4406	****	-0.3430	****	0.0217		-0.0518	-0.0073		-0.0425	*	0.0129	-0.0100	***	85.23%	168.32	****
2009	0.0007		0.6418	****	-0.3556	****	-0.2355	****	-0.0713		-0.7302	0.0095		0.0180		-0.0046	-0.0084		72.11%	75.71	****
2010	-0.0017		0.8555	****	-0.1834	***	-0.1437	****	-0.1547	****	0.7026	0.0318		-0.0507	**	0.0069	-0.0053		84.76%	161.66	****
2011	0.0014		0.8680	****	-0.3269	****	0.0992	*	-0.0646	*	-0.7541	0.0382		-0.0360		0.0241	0.0090		82.20%	133.86	****
2012	0.0010		0.8363	****	-0.1544	**	0.1866	****	-0.2195	***	-0.8308	-0.0302		-0.0305		0.0092	0.0181		71.87%	74.81	****
2013^A	-0.0011		0.8099	****	-0.3245	****	0.2385	****	-0.2103	**	0.6038	-0.0770		0.0033		-0.0283	0.0011		70.02%	34.22	****
Mean:	0.0002		0.6352		-0.3280		-0.0250		-0.0162		-0.0697	0.0020		-0.0268		0.0019	0.0030		68.33%		

^{A} Due to rebalancing in June, data contains six months of observations.

TABLE D.3: INTER-TEMPORAL ANALYSIS OF LOW-BE/ME PORTFOLIO USING THE LOCAL AFFM

This table presents conditional annual local AFFM, estimated on a year-by-year basis using Newey-West HAC standard errors between 1996 and 2013. The value-weighted returns of the low-BE/ME portfolio ($\boldsymbol{R_{low}}$) is used as the dependent variable. The nine risk factors include: market premium ($\boldsymbol{R_m}$), local size premium ($LSMB$), local value premium ($LHML$), local momentum premium ($LUMD$), term premium ($\boldsymbol{R_{tp}}$), oil risk (R_o), coal risk (R_c), natural gas risk (R_g) and carbon risk (R_{co2}). The intercept and error term is denoted α_i and e, respectively. A ****, ***, ** or * denotes significance at 0.1%, 1%, 5% or 10%, respectively. The specification used is:

$$\boldsymbol{R_{low}} = \alpha_i + b_i\boldsymbol{R}_m + s_iLSMB + h_iLHML + m_iLUMD + tp_i\boldsymbol{R}_{tp} + o_iR_o + c_iR_{co} + g_iR_g + co2_iR_{co2} + e$$

Year	α_i		b_i		s_i		h_i		m_i		tp_i		o_i		c_i		g_i		$co2_i$	$\boldsymbol{adj.R^2}$	$\boldsymbol{F =}$	***Sig.***
1996[A]	-0.0001		0.4400	****	-0.4968	****	-0.2347	****	-0.0741		1.0701	****	-0.0004		-0.0507		-0.0082			54.59%	20.68	****
1997	0.0002		0.4339	****	-0.4735	****	-0.2093	****	0.0312		-0.1748		0.0140		0.0219		0.0065			56.22%	42.73	****
1998	0.0005		0.3509	****	-0.4136	****	-0.3101	****	-0.0824	*	0.0967		0.0379	**	0.0091		-0.0005			57.12%	44.29	****
1999	-0.0001		0.3591	****	-0.5947	****	-0.4195	****	-0.1419	**	0.0937		-0.0390	*	0.0206		-0.0071			63.69%	58.00	****
2000	0.0008		0.3183	****	-0.4040	****	-0.2719	****	0.0192		-0.9404	*	0.0111		0.0548		0.0023			44.16%	26.60	****
2001	0.0004		0.4038	****	-0.3451	****	-0.1945	****	-0.0810		0.3614		0.0091		0.0387		0.0062			59.54%	48.83	****
2002	-0.0004		0.2799	****	-0.3025	****	-0.1535	****	-0.0786	**	-0.1780		-0.0394		0.0624		0.0078			70.55%	78.87	****
2003	0.0006	**	0.3905	****	-0.4545	****	-0.3139	****	-0.1128	***	0.2936		-0.0128		-0.0409		-0.0089			80.41%	134.41	****
2004	0.0008	***	0.5744	****	-0.2359	****	-0.1680	****	0.0570		0.0316		0.0052		-0.0035		0.0045			57.21%	44.63	****
2005	0.0005		0.9060	****	-0.0969	**	-0.1872	****	0.1134	*	0.3617		-0.0038		-0.0243		-0.0028			61.45%	52.60	****
2006	0.0005	**	0.6948	****	-0.1090	****	-0.2244	****	-0.0369		0.1236		0.0381	**	0.0064		0.0054		0.0014	63.34%	50.72	****
2007	0.0003		0.5282	****	-0.2182	****	-0.1803	****	0.0927	*	-0.5295		0.0758	***	-0.0027		-0.0056		0.0017	54.35%	35.40	****
2008	-0.0004		0.5267	****	-0.4013	****	-0.5189	****	-0.0256		0.2874		0.0551	*	-0.0633	***	0.0343	**	0.0038	80.35%	119.56	****
2009	-0.0004		0.4441	****	-0.4462	****	-0.4469	****	-0.1598	***	0.1093		0.0223		0.0495	***	-0.0082		0.0152	75.82%	91.56	****
2010	-0.0177	**	0.5007	****	-0.4349	****	-0.3346	****	-0.0678	*	10.0670	**	0.0646	***	-0.0300		0.0054		-0.0044	71.23%	72.52	****
2011	-0.0013		0.7587	****	-0.2134	***	-0.1249	*	-0.0932	**	0.2953		0.0168		0.0357		-0.0223		0.0049	76.56%	95.02	****
2012	-0.0010		0.5730	****	-0.0809	*	-0.0834	***	-0.1350	****	0.5692		-0.0139		-0.0032		-0.0571	**	0.0121	52.45%	32.87	****
2013 [A]	-0.0037		0.6389	****	-0.0091		-0.2500	****	-0.1819	***	2.0413		0.0184		0.0398		-0.0618	*	0.0108	42.47%	11.50	****
Mean:	-0.0011		0.5068		-0.3184		-0.2570		-0.0532		0.7766		0.0144		0.0067		-0.0061		0.0057	62.31%		

[A] Due to rebalancing in June, data contains six months of observations.

TABLE D.4: INTER-TEMPORAL ANALYSIS OF UPPER MOMENTUM PORTFOLIO USING THE LOCAL AFFM

This table presents conditional annual local AFFM, estimated on a year-by-year basis using Newey-West HAC standard errors between 1996 and 2013. The value-weighted returns of the upper momentum portfolio ($\boldsymbol{R_{upper}}$) is used as the dependent variable. The nine risk factors include: market premium ($\boldsymbol{R_m}$), local size premium ($LSMB$), local value premium ($LHML$), local momentum premium ($LUMD$), term premium ($\boldsymbol{R_{tp}}$), oil risk (R_o), coal risk (R_c), natural gas risk (R_g) and carbon risk (R_{co2}). The intercept and error term is denoted α_i and e, respectively. A ****, ***, ** or * denotes significance at 0.1%, 1%, 5% or 10%, respectively. The specification used is:

$$\boldsymbol{R_{upper}} = \alpha_i + b_i\boldsymbol{R_m} + s_iLSMB + h_iLHML + m_iLUMD + tp_i\boldsymbol{R_{tp}} + o_iR_o + c_iR_{co} + g_iR_g + co2_iR_{co2} + e$$

Year	α_i	b_i	s_i	h_i	m_i	tp_i	o_i	c_i	g_i	$co2_i$	$\boldsymbol{adj.R^2}$	$\boldsymbol{F=}$	***Sig.***
1996^A	0.0002	0.3344 ****	-0.2382 ****	-0.0023	0.4795 ****	0.2458	-0.0093	-0.0122	-0.0048		67.02%	34.27	****
1997	0.0007 ***	0.1959 ****	-0.0686 *	0.0162	0.6927 ****	-0.1475	0.0098	-0.0490 *	0.0053		80.48%	135.00	****
1998	0.0006 *	0.2368 ****	-0.1395 ****	-0.0497	0.3915 ****	0.0910	0.0123	-0.0075	-0.0008		67.50%	68.49	****
1999	-0.0005 *	0.1755 ****	-0.3527 ****	0.0792 **	0.5015 ****	0.0769	0.0260 *	0.0356 **	0.0060		64.29%	59.51	****
2000	0.0008 *	0.1737 ****	-0.1738 ****	-0.0052	0.6126 ****	-0.0767	0.0156	-0.0290	-0.0098		67.54%	68.38	****
2001	0.0004	0.2104 ****	-0.1613 ****	-0.0246	0.4728 ****	-0.0390	0.0072	0.0328	-0.0015		50.41%	34.03	****
2002	0.0002	0.2435 ****	-0.2354 ****	0.0610	0.4827 ****	-0.8698 *	-0.0127	-0.0294	0.0058		60.08%	49.92	****
2003	0.0003	0.1262 ****	-0.1730 ****	0.0002	0.2826 ****	0.1074	-0.0008	0.0073	-0.0067 *		42.08%	24.61	****
2004	0.0006 ***	0.2693 ****	-0.1310 ****	0.0040	0.5740 ****	-0.0569	-0.0084	-0.0052	0.0062		73.14%	89.86	****
2005	0.0002	0.3641 ****	0.0135	0.0139	0.6878 ****	0.1501	-0.0145	-0.0167	0.0002		68.77%	72.29	****
2006	0.0001	0.3627 ****	-0.0208	-0.0291	0.5686 ****	-0.0698	0.0040	-0.0110	0.0061 **	0.0113 ****	74.02%	82.98	****
2007	0.0005 **	0.2984 ****	-0.0734 **	-0.0610 **	0.4984 ****	-0.1706	0.0339 **	-0.0079	0.0003	-0.0015 **	62.51%	49.16	****
2008	-0.0001	0.2565 ****	-0.1121 **	-0.2097 ****	0.4449 ****	0.4696 *	0.0186	0.0018	0.0188 ***	-0.0017	72.62%	77.93	****
2009	0.0003	0.1698 ****	-0.1717 ****	-0.1440 ****	0.4076 ****	-0.2086	0.0357 ***	0.0166	0.0145 *	0.0169	49.08%	28.85	****
2010	-0.0042	0.3097 ****	-0.1397 ****	-0.1124 ****	0.3553 ****	2.5128	0.0289	-0.0065	0.0010	-0.0074	64.39%	53.23	****
2011	0.0011	0.3631 ****	-0.0732 *	-0.0120	0.3542 ****	-0.7132	0.0384 *	-0.0086	0.0027	0.0114	65.89%	56.60	****
2012	-0.0004	0.3729 ****	-0.0964 ***	0.0400	0.2434 ****	0.1418	-0.0012	-0.0034	-0.0077	-0.0062	52.53%	32.97	****
2013^A	0.0013	0.3793 ****	-0.0551	0.0893 **	0.3904 ****	-0.6031	0.0243	0.0022	-0.0494 *	0.0058	60.07%	22.40	****
Mean:	0.0001	0.2690	-0.1335	-0.0192	0.4689	0.0467	0.0115	-0.0050	-0.0008	0.0036	63.47%		

^{A} Due to rebalancing in June, data contains six months of observations.

TABLE D.5: INTER-TEMPORAL ANALYSIS OF MEDIUM MOMENTUM PORTFOLIO USING THE LOCAL AFFM

This table presents conditional annual local AFFM, estimated on a year-by-year basis using Newey-West HAC standard errors between 1996 and 2013. The value-weighted returns of the medium momentum portfolio ($\boldsymbol{R_{medium}}$) is used as the dependent variable. The nine risk factors include: market premium ($\boldsymbol{R_m}$), local size premium ($LSMB$), local value premium ($LHML$), local momentum premium ($LUMD$), term premium ($\boldsymbol{R_{tp}}$), oil risk (R_o), coal risk (R_c), natural gas risk (R_g) and carbon risk (R_{co2}). The intercept and error term is denoted α_i and e, respectively. A ****, ***, ** or * denotes significance at 0.1%, 1%, 5% or 10%, respectively. The specification used is:

$$\boldsymbol{R_{medium}} = \alpha_i + b_i\boldsymbol{R}_m + s_i LSMB + h_i LHML + m_i LUMD + tp_i\boldsymbol{R}_{tp} + o_i R_o + c_i R_{co} + g_i R_g + co2_i R_{co2} + e$$

Year	α_i	b_i	s_i	h_i	m_i	tp_i	o_i	c_i	g_i	$co2_i$	$adj.R^2$	$F =$	Sig.
1996[A]	0.0000	0.4734 ****	-0.3540 *	0.1008	0.1691 **	0.6808 *	-0.0048	-0.0973	-0.0047		42.24%	12.98	****
1997	0.0003	0.7019 ****	-0.3228 ****	0.0108	-0.0915 **	-0.5271 *	-0.0077	0.0260	0.0144		71.45%	82.35	****
1998	0.0001	0.4001 ****	-0.3868 ****	-0.0016	-0.0130	0.1255	-0.0074	-0.0956 **	-0.0023		56.24%	42.77	****
1999	0.0001	0.3108 ****	-0.6111 ****	0.0102	0.0030	0.1911	-0.0254	0.0276	0.0006		55.86%	42.13	****
2000	0.0005	0.1554 ***	-0.5195 ****	0.0300	0.0095	-0.3770	-0.0005	0.0931	0.0116		27.20%	13.10	****
2001	0.0008	0.3817 ****	-0.4168 ****	-0.0992	0.0444	0.2498	0.0345 *	-0.0125	0.0078		52.37%	36.74	****
2002	0.0005	0.3473 ****	-0.3027 ****	-0.0438	-0.0123	-0.0339	-0.0399	0.0237	0.0196		63.06%	56.49	****
2003	0.0002	0.3986 ****	-0.3258 ****	-0.1098 ***	0.0552	0.0691	0.0066	-0.0759 **	0.0014		67.67%	69.02	****
2004	0.0007 **	0.5485 ****	-0.1984 ****	-0.0814 **	0.0611	0.1664	0.0057	-0.0392	0.0094		52.56%	37.14	****
2005	0.0006	0.9585 ****	-0.1484 ****	-0.1555 ****	0.0614	0.1529	-0.0086	-0.0272	0.0025		63.75%	57.95	****
2006	0.0008 **	0.8279 ****	-0.2035 ****	-0.1516 ***	0.1200 **	0.2642	0.0509 **	-0.0127	-0.0028	0.0042	62.56%	49.08	****
2007	0.0006	0.6905 ****	-0.2807 ****	0.0063	-0.0325	-0.7057	0.0486 *	0.0231	-0.0036	0.0006	63.82%	51.95	****
2008	0.0003	0.6744 ****	-0.5190 ****	-0.3852 ****	0.0482	-0.1099	0.0022	-0.0506 *	0.0182	-0.0088 *	83.14%	144.04	****
2009	-0.0002	0.6065 ****	-0.4144 ****	-0.1988 ****	-0.0284	-0.2268	0.0090	-0.0054	-0.0116	-0.0144	69.51%	66.85	****
2010	-0.0016	0.7306 ****	-0.3208 ****	0.0208	-0.0114	0.6162	0.0333	-0.0342	-0.0009	-0.0093	82.07%	133.24	****
2011	-0.0002	0.7863 ****	-0.2633 ****	0.0809 *	-0.0168	0.2662	0.0307	-0.0247	0.0215	-0.0006	83.28%	144.32	****
2012	0.0017	0.6941 ****	-0.1712 ***	0.1519 ****	-0.1960 ****	-1.1958	-0.0189	-0.0301	-0.0326	0.0251 *	63.82%	51.95	****
2013[A]	-0.0043	0.8111 ****	-0.2139 ***	0.0950 *	-0.0580	2.3989	-0.0661	-0.0415	0.0142	-0.0003	65.69%	28.23	****
Mean:	0.0001	0.5832	-0.3318	-0.0400	0.0062	0.1114	0.0023	-0.0196	0.0035	-0.0004	62.57%		

[A] Due to rebalancing in June, data contains six months of observations.

TABLE D.6: INTER-TEMPORAL ANALYSIS OF DOWN MOMENTUM PORTFOLIO USING THE LOCAL AFFM

This table presents conditional annual local AFFM, estimated on a year-by-year basis using Newey-West HAC standard errors between 1996 and 2013. The value-weighted returns of the down momentum portfolio ($\boldsymbol{R_{down}}$) is used as the dependent variable. The nine risk factors include: market premium ($\boldsymbol{R_m}$), local size premium ($LSMB$), local value premium ($LHML$), local momentum premium ($LUMD$), term premium ($\boldsymbol{R_{tp}}$), oil risk (R_o), coal risk (R_c), natural gas risk (R_g) and carbon risk (R_{co2}). The intercept and error term is denoted α_i and e, respectively. A ****, ***, ** or * denotes significance at 0.1%, 1%, 5% or 10%, respectively. The specification used is:

$$\boldsymbol{R_{down}} = \alpha_i + b_i\boldsymbol{R}_m + s_iLSMB + h_iLHML + m_iLUMD + tp_i\boldsymbol{R}_{tp} + o_iR_o + c_iR_{co} + g_iR_g + co2_iR_{co2} + e$$

Year	α_i		b_i		s_i		h_i		m_i		tp_i		o_i		c_i		g_i		$co2_i$		$\boldsymbol{adj.R^2}$	$\boldsymbol{F=}$	***Sig.***
1996^A	0.0002		0.3344	****	-0.2382	****	-0.0023		-0.5205	****	0.2458		-0.0093		-0.0122		-0.0048				73.00%	45.28	****
1997	0.0007	***	0.1959	****	-0.0686	*	0.0162		-0.3073	****	-0.1475		0.0098		-0.0490	*	0.0053				41.35%	23.91	****
1998	0.0006	*	0.2368	****	-0.1395	****	-0.0497		-0.6085	****	0.0910		0.0123		-0.0075		-0.0008				77.75%	114.56	****
1999	-0.0005	*	0.1755	****	-0.3527	****	0.0792	**	-0.4985	****	0.0769		0.0260	*	0.0356	**	0.0060				68.94%	73.12	****
2000	0.0008	*	0.1737	****	-0.1738	****	-0.0052		-0.3874	****	-0.0767		0.0156		-0.0290		-0.0098				48.40%	31.36	****
2001	0.0004		0.2104	****	-0.1613	****	-0.0246		-0.5272	****	-0.0390		0.0072		0.0328		-0.0015				71.06%	80.81	****
2002	0.0002		0.2435	****	-0.2354	****	0.0610		-0.5173	****	-0.8698	*	-0.0127		-0.0294		0.0058				85.36%	190.46	****
2003	0.0003		0.1262	****	-0.1730	****	0.0002		-0.7174	****	0.1074		-0.0008		0.0073		-0.0067	*			91.85%	367.11	****
2004	0.0006	***	0.2693	****	-0.1310	****	0.0040		-0.4260	****	-0.0570		-0.0084		-0.0052		0.0062				55.34%	41.42	****
2005	0.0002		0.3641	****	0.0135		0.0139		-0.3122	****	0.1502		-0.0145		-0.0167		0.0002				38.59%	21.34	****
2006	0.0001		0.3627	****	-0.0208		-0.0291		-0.4314	****	-0.0698		0.0040		-0.0110		0.0061	**	0.0113	****	62.44%	48.83	****
2007	0.0005	**	0.2984	****	-0.0734	**	-0.0610	**	-0.5016	****	-0.1706		0.0339	**	-0.0079		0.0003		-0.0015	**	68.06%	62.57	****
2008	-0.0001		0.2565	****	-0.1121	**	-0.2097	****	-0.5551	****	0.4696	*	0.0186		0.0018		0.0188	***	-0.0017		86.48%	186.47	****
2009	0.0003		0.1698	****	-0.1717	****	-0.1440	****	-0.5924	****	-0.2086		0.0357	***	0.0166		0.0145	*	0.0169		81.69%	129.92	****
2010	-0.0042		0.3097	****	-0.1397	****	-0.1124	****	-0.6447	****	2.5129		0.0289		-0.0065		0.0010		-0.0074		81.73%	130.22	****
2011	0.0011		0.3631	****	-0.0733	*	-0.0120		-0.6458	****	-0.7132		0.0384	*	-0.0086		0.0027		0.0114		88.62%	225.09	****
2012	-0.0004		0.3729	****	-0.0964	***	0.0400		-0.7566	****	0.1418		-0.0012		-0.0034		-0.0077		-0.0062		89.14%	238.06	****
2013 ^{A}	0.0013		0.3793	****	-0.0551		0.0893	**	-0.6096	****	-0.6030		0.0243		0.0022		-0.0494	*	0.0058		71.78%	37.17	****
Mean:	0.0001		0.2690		-0.1335		-0.0192		-0.5311		0.0467		0.0115		-0.0050		-0.0008		0.0036		71.20%		

^{A} Due to rebalancing in June, data contains six months of observations.

TABLE D.7: INTER-TEMPORAL ANALYSIS OF ELECTRICITY-UTILITY PORTFOLIO USING THE LOCAL AFFM

This table presents conditional annual local AFFM, estimated on a year-by-year basis using Newey-West HAC standard errors between 1996 and 2013. The value-weighted returns of the electricity portfolio ($\boldsymbol{R_{elecutil}}$) is used as the dependent variable. The nine risk factors include: market premium ($\boldsymbol{R_m}$), local size premium ($LSMB$), local value premium ($LHML$), local momentum premium ($LUMD$), term premium ($\boldsymbol{R_{tp}}$), oil risk (R_o), coal risk (R_c), natural gas risk (R_g) and carbon risk (R_{co2}). The intercept and error term is denoted α_i and e, respectively. A ****, ***, ** or * denotes significance at 0.1%, 1%, 5% or 10%, respectively. The specification used is:

$$\boldsymbol{R_{elecutil}} = \alpha_i + b_i\boldsymbol{R}_m + s_iLSMB + h_iLHML + m_iLUMD + tp_i\boldsymbol{R}_{tp} + o_iR_o + c_iR_{co} + g_iR_g + co2_iR_{co2} + e$$

Year	α_i	b_i	s_i	h_i	m_i	tp_i	o_i	c_i	g_i	$co2_i$	$\boldsymbol{adj.R^2}$	$\boldsymbol{F =}$	**Sig.**
1996[A]	0.0000	0.4756 ****	-0.3802 **	0.0655	-0.0941 *	0.7704 **	-0.0366 **	-0.1304	-0.0039		51.65%	18.49	****
1997	0.0006	0.4699 ****	-0.3225 ****	0.0397	0.2698 ****	-0.3150	0.0390	0.0197	0.0112		60.61%	51.01	****
1998	0.0010 **	0.4630 ****	-0.2028 ****	-0.0001	0.1145 ***	0.1388	-0.0037	0.0006	0.0049		70.29%	77.91	****
1999	-0.0003	0.3900 ****	-0.3458 ****	-0.1115 **	0.0667	-0.0082	-0.0691 ****	0.0449 **	-0.0100		53.42%	38.28	****
2000	0.0005	0.2124 ****	-0.3166 ****	-0.0523	-0.0172	0.1115	0.0161	0.0329	-0.0020		33.62%	17.40	****
2001	-0.0002	0.3486 ****	-0.2944 ****	0.0391	-0.2242 ***	-0.1177	-0.0019	0.0291	0.0079		59.63%	49.00	****
2002	-0.0003	0.2663 ****	-0.2977 ****	0.1035 *	-0.1089 **	-0.0771	-0.0187	-0.0296	0.0121		56.00%	42.36	****
2003	0.0009 ***	0.4282 ****	-0.4329 ****	-0.1803 ****	-0.1293 **	0.0084	-0.0144	-0.0399	0.0025		73.01%	88.91	****
2004	0.0007 **	0.5571 ****	-0.2108 ****	-0.0320	0.1945 ***	0.2813	-0.0011	-0.0416	0.0116		47.49%	30.51	****
2005	0.0004	0.7222 ****	-0.0019	-0.0106	-0.0063	0.0619	-0.0067	-0.0119	0.0056		44.90%	27.38	****
2006	0.0006	0.8110 ****	-0.0560	0.0270	0.0943	0.0592	0.0881 ***	-0.0044	0.0033	0.0263 ****	60.34%	44.79	****
2007	0.0008	0.5877 ****	-0.2613 ****	0.1647 ***	0.0340	-0.8856	0.1007 ***	0.0194	0.0014	0.0012	48.24%	27.92	****
2008	0.0000	0.6060 ****	-0.3447 ****	-0.4283 ****	0.0014	-0.0516	0.0569	-0.0536 *	0.0525 ***	0.0006	75.82%	91.96	****
2009	-0.0005	0.5841 ****	-0.2657 ****	-0.2309 ****	-0.1550 ****	0.1607	0.0421 *	0.0666 ****	-0.0166 *	0.0171	71.52%	73.53	****
2010	-0.0146 **	0.5802 ****	-0.2187 ****	-0.1652 ****	-0.1077 ***	8.2653 **	0.0438 **	-0.0257	0.0089	0.0147	74.07%	83.51	****
2011	0.0002	0.7725 ****	-0.0798	0.0406	-0.1140 **	-0.3479	0.0479	0.0174	-0.0008	-0.0040	71.81%	74.31	****
2012	-0.0008	0.5560 ****	-0.0445	0.1416 ****	-0.1369 **	0.3973	-0.0026	-0.0352 **	-0.0216	0.0267 **	56.95%	39.21	****
2013 [A]	0.0002	0.4079 ****	-0.1427 **	0.0674	-0.3009 ****	0.0308	0.0297	0.0050	-0.0252	0.0092	52.22%	16.54	****
Mean:	-0.0006	0.5133	-0.2344	-0.0290	-0.0344	0.4713	0.0172	-0.0076	0.0023	0.0115	58.98%		

[A] Due to rebalancing in June, data contains six months of observations.

TABLE D.8: INTER-TEMPORAL ANALYSIS OF NATURAL GAS-UTILITY PORTFOLIO USING THE LOCAL AFFM

This table presents conditional annual local AFFM, estimated on a year-by-year basis using Newey-West HAC standard errors between 1996 and 2013. The value-weighted returns of the natural gas portfolio ($\boldsymbol{R_{gasutil}}$) is used as the dependent variable. The nine risk factors include: market premium ($\boldsymbol{R_m}$), local size premium ($LSMB$), local value premium ($LHML$), local momentum premium ($LUMD$), term premium ($\boldsymbol{R_{tp}}$), oil risk (R_o), coal risk (R_c), natural gas risk (R_g) and carbon risk (R_{co2}). The intercept and error term is denoted α_i and e, respectively. A ****, ***, ** or * denotes significance at 0.1%, 1%, 5% or 10%, respectively. The specification used is:

$$\boldsymbol{R_{gasutil}} = \alpha_i + b_i\boldsymbol{R}_m + s_i LSMB + h_i LHML + m_i LUMD + tp_i\boldsymbol{R}_{tp} + o_i R_o + c_i R_{co} + g_i R_g + co2_i R_{co2} + e$$

Year	α_i	b_i	s_i	h_i	m_i	tp_i	o_i	c_i	g_i	$co2_i$	$\boldsymbol{adj.R^2}$	$\boldsymbol{F=}$	***Sig.***
1996^A	-0.0014	0.9479 **	-0.6848	-0.1610	-0.0654	2.6625 ***	-0.0486	-0.2520	0.0650		17.50%	4.47	****
1997	-0.0004	0.6813 ****	-0.2128 *	-0.0715	0.3063 ***	-0.3870	0.0390	0.0689	-0.0139		48.14%	31.17	****
1998	0.0003	0.7213 ****	-0.5392 ****	0.0898	-0.0675	0.0139	0.0448	-0.1278	-0.0107		50.66%	34.37	****
1999	-0.0002	0.3833 ****	-0.7406 ****	0.1542 *	0.0867	0.1423	0.1333 ****	0.1270 ***	0.0491		41.41%	23.97	****
2000	0.0012	0.1676 **	-0.7793 ****	-0.1353	0.3127 ****	-0.2193	0.0696	0.1341	0.0165		25.06%	11.82	****
2001	0.0011	0.5669 ****	-0.4291 ****	-0.1034	0.4484 ****	0.4888	0.0843 **	-0.0457	-0.0157		32.53%	16.67	****
2002	0.0008	0.6788 ****	-0.5093 ****	-0.0387	0.1984 ****	-0.3175	0.0094	-0.0863	0.0133		63.51%	57.56	****
2003	0.0002	0.5127 ****	-0.3617 ****	-0.2292 ****	-0.0203	0.4204	0.0148	-0.0795	0.0060		61.64%	53.21	****
2004	0.0009 *	0.5731 ****	-0.2728 ****	-0.2064 ****	0.0419	0.0400	0.0215	-0.0035	0.0028		39.95%	22.70	****
2005	0.0003	1.0614 ****	-0.1096 *	-0.1954 ****	0.0806	0.1169	0.0246	-0.0605 *	0.0038		48.35%	31.31	****
2006	0.0002	0.8086 ****	-0.1030 *	-0.2119 ****	-0.1653 *	0.2331	0.0739 ***	0.0181	0.0027	0.0057	49.30%	28.99	****
2007	0.0002	0.7279 ****	-0.1659 ***	-0.1568 ***	-0.1907 ****	-0.4654	0.0391	-0.0479 *	0.0039	0.0002	64.31%	53.05	****
2008	0.0005	0.7996 ****	-0.4206 ****	-0.3017 ****	0.0025	-0.1630	-0.0496	-0.0099	0.0001	0.0058	77.08%	98.54	****
2009	0.0023	0.7347 ****	-0.1230	-0.1859 ***	-0.0789	-1.5111	0.0069	0.0147	-0.0032	-0.0259	58.75%	42.15	****
2010	-0.0035	0.8123 ****	-0.1743 **	-0.1076 **	-0.0487	1.9819	0.0153	-0.0301	-0.0049	0.0038	75.87%	91.83	****
2011	0.0008	0.8628 ****	-0.2361 ****	0.0363	0.0245	-0.3238	0.0399	0.0094	0.0377 *	-0.0099	77.51%	100.18	****
2012	0.0000	0.9534 ****	-0.2278 ****	0.0876 **	-0.0041	0.1518	-0.0078	-0.0037	0.0442 *	-0.0157	68.77%	64.62	****
2013^A	-0.0019	0.8121 ****	-0.2499 **	0.0810	0.0291	0.7552	-0.0602	-0.0311	0.0057	0.0007	50.70%	15.62	****
Mean:	0.0001	0.7114	-0.3522	-0.0920	0.0494	0.2011	0.0250	-0.0225	0.0112	-0.0044	52.84%		

[A] Due to rebalancing in June, data contains six months of observations.

Table D.9: Inter-Temporal Analysis of Multi-Utility Portfolio using the Local AFFM

This table presents conditional annual local AFFM, estimated on a year-by-year basis using Newey-West HAC standard errors between 1996 and 2013. The value-weighted returns of the multi-utility portfolio ($\boldsymbol{R_{multi}}$) is used as the dependent variable. The nine risk factors include: market premium ($\boldsymbol{R_m}$), local size premium ($LSMB$), local value premium ($LHML$), local momentum premium ($LUMD$), term premium ($\boldsymbol{R_{tp}}$), oil risk (R_o), coal risk (R_c), natural gas risk (R_g) and carbon risk (R_{co2}). The intercept and error term is denoted α_i and e, respectively. A ****, ***, ** or * denotes significance at 0.1%, 1%, 5% or 10%, respectively. The specification used is:

$$\boldsymbol{R_{multi}} = \alpha_i + b_i\boldsymbol{R}_m + s_iLSMB + h_iLHML + m_iLUMD + tp_i\boldsymbol{R}_{tp} + o_iR_o + c_iR_{co} + g_iR_g + co2_iR_{co2} + e$$

Year	α_i	b_i	s_i	h_i	m_i	tp_i	o_i	c_i	g_i	$co2_i$	$\boldsymbol{adj.R^2}$	$\boldsymbol{F =}$	**Sig.**
1996^{A}	0.0004	0.5625 ****	-0.4948 ****	-0.0987	0.3677 ***	0.0027	-0.0026	0.0796	-0.0207 *		51.11%	18.12	****
1997	0.0005	0.6570 ****	-0.3820 ****	-0.0909	-0.0917	-0.4963	-0.0313	-0.0111	0.0187		49.84%	33.30	****
1998	-0.0003	0.3701 ****	-0.2729 ****	-0.1379 **	-0.1863 ***	-0.1075	0.0086	-0.1301 ***	0.0025		41.55%	24.10	****
1999	0.0001	0.2199 ***	-0.8360 ****	-0.1007	-0.1927 **	0.0086	0.0075	-0.0196	-0.0169		38.04%	20.95	****
2000	0.0012	0.1583 ***	-0.4197 ****	0.0176	-0.0809	-1.0490 *	-0.0385	-0.0357	0.0091		19.99%	9.09	****
2001	0.0005	0.3202 ****	-0.3579 ****	-0.1371 **	-0.0840	0.2730	0.0022	-0.0029	0.0074		48.33%	31.40	****
2002	0.0004	0.5322 ****	-0.2797 ****	0.0405	-0.0921 **	-0.2532	-0.0597 **	0.0481	-0.0008		79.05%	123.65	****
2003	0.0005 *	0.4224 ****	-0.2731 ****	-0.0734 *	-0.0102	0.1984	-0.0003	-0.0655 **	-0.0131 *		71.43%	82.26	****
2004	0.0009 ***	0.5509 ****	-0.2104 ****	0.0105	0.0105	-0.0815	-0.0020	-0.0243	-0.0005		60.43%	50.82	****
2005	0.0004	0.7372 ****	-0.1206 **	-0.1230 ***	0.1229	0.0627	-0.0258	-0.0041	-0.0075		48.61%	31.62	****
2006	0.0007 **	0.6141 ****	-0.2160 ****	-0.1180 ***	0.1982 ***	0.0828	0.0137	-0.0088	0.0000	-0.0056	54.68%	35.72	****
2007	0.0005	0.5487 ****	-0.2089 ****	-0.1218 ****	0.1381 **	-0.5051	0.0376 *	-0.0065	-0.0130 **	0.0010	58.98%	42.53	****
2008	0.0002	0.6401 ****	-0.5241 ****	-0.4049 ****	0.0352	0.3179	0.0010	-0.0684 **	0.0116	-0.0084 *	78.96%	109.83	****
2009	-0.0003	0.5408 ****	-0.5173 ****	-0.4105 ****	-0.1263 **	0.0262	-0.0007	0.0473 **	0.0010	-0.0084	73.23%	80.03	****
2010	-0.0051	0.8307 ****	-0.2789 ****	-0.2161 ****	-0.1463 ****	2.6826	0.0511 **	-0.0596 **	0.0093	-0.0293	81.36%	127.10	****
2011	0.0001	0.8114 ****	-0.3763 ****	0.1114	-0.0536	-0.1375	0.0066	-0.0336	0.0037	0.0201	79.72%	114.12	****
2012	0.0015	0.6360 ****	-0.1729 **	0.1867 ****	-0.2500 ****	-1.1037	-0.0405	-0.0306	-0.0131	-0.0020	62.25%	48.64	****
2013^{A}	-0.0004	0.5338 ****	-0.2407 ****	0.1038 **	-0.1476 ***	0.3417	-0.0575	0.0233	-0.0359	0.0015	67.37%	30.36	****
Mean:	0.0001	0.5381	-0.3435	-0.0868	-0.0327	0.0146	-0.0073	-0.0168	-0.0032	-0.0039	59.16%		

[A] Due to rebalancing in June, data contains six months of observations.

TABLE D.10: INTER-TEMPORAL ANALYSIS OF SMALL UTILITIES PORTFOLIO USING THE LOCAL AFFM

This table presents conditional annual local AFFM, estimated on a year-by-year basis using Newey-West HAC standard errors between 1996 and 2013. The value-weighted returns of the small utility portfolio ($\boldsymbol{R_{small}}$) is used as the dependent variable. The nine risk factors include: market premium ($\boldsymbol{R_m}$), local size premium ($LSMB$), local value premium ($LHML$), local momentum premium ($LUMD$), term premium ($\boldsymbol{R_{tp}}$), oil risk (R_o), coal risk (R_c), natural gas risk (R_g) and carbon risk (R_{co2}). The intercept and error term is denoted α_i and e, respectively. A ****, ***, ** or * denotes significance at 0.1%, 1%, 5% or 10%, respectively. The specification used is:

$$\boldsymbol{R_{small}} = \alpha_i + b_i\boldsymbol{R}_m + s_iLSMB + h_iLHML + m_iLUMD + tp_i\boldsymbol{R_{tp}} + o_iR_o + c_iR_{co} + g_iR_g + co2_iR_{co2} + e$$

Year	α_i	b_i	s_i	h_i	m_i	tp_i	o_i	c_i	g_i	$co2_i$	$adj.R^2$	$F =$	Sig.
1996[A]	-0.0001	0.4333 ****	0.3922 ****	0.2427 ****	0.0276	0.6542 ****	-0.0091	-0.0273	-0.0073		62.94%	28.81	****
1997	0.0002	0.3732 ****	0.2993 ****	0.0739 **	0.0168	-0.2364	0.0162	0.0077	0.0036		55.28%	41.17	****
1998	0.0005	0.3447 ****	0.3652 ****	0.0655	-0.0602 *	0.1161	0.0178	-0.0094	-0.0061		51.74%	35.84	****
1999	-0.0002	0.2601 ****	0.1579 ***	0.1291 ***	-0.0333	0.1359	-0.0044	0.0062	-0.0043		23.74%	11.12	****
2000	0.0007	0.2021 ****	0.3772 ****	-0.0202	-0.0162	-0.8204 *	-0.0163	0.1278 **	-0.0152		21.07%	9.64	****
2001	0.0000	0.2708 ****	0.2782 ****	0.1561 **	0.0050	0.0474	-0.0026	-0.0066	0.0082		31.10%	15.67	****
2002	-0.0013	0.4017 ****	0.6165 ****	0.5090 ****	-0.0386	1.0659	-0.0300	-0.0060	0.0005		33.10%	17.08	****
2003	0.0002	0.3872 ****	0.3561 ****	0.0946 ***	-0.1088 ***	0.3439 *	-0.0198	-0.0215	0.0001		41.33%	23.89	****
2004	0.0009 ****	0.4857 ****	0.5661 ****	0.2802 ****	0.0537	0.1421	0.0029	-0.0325	0.0047		63.89%	58.72	****
2005	0.0005	0.7924 ****	0.6008 ****	0.2016 ****	0.1161 *	0.2235	-0.0141	0.0082	-0.0015		68.41%	71.11	****
2006	0.0005	0.6858 ****	0.5125 ****	-0.0913 **	0.0292	-0.2779	0.0844 ****	0.0002	0.0015	0.0126 **	57.94%	40.65	****
2007	0.0005	0.6242 ****	0.4407 ****	0.0427	0.0327	-0.7237 *	0.0735 ***	0.0106	-0.0051	0.0036	67.90%	62.10	****
2008	-0.0002	0.4842 ****	0.4689 ****	-0.1076	0.0312	0.0153	0.0209	-0.0461 **	0.0261 **	-0.0023	63.90%	52.33	****
2009	0.0016	0.4545 ****	0.1923 ****	-0.0900 **	-0.0407	-0.9220	0.0259	0.0424 *	-0.0064	-0.0181	56.05%	37.84	****
2010	-0.0115	0.6727 ****	0.2606 ****	0.1274 ***	-0.0745 **	6.3937	0.0610 ***	-0.0413 *	0.0029	-0.0077	69.25%	66.07	****
2011	0.0002	0.7821 ****	0.5167 ****	0.0602	-0.0049	-0.2048	0.0220	-0.0240	0.0162	0.0035	71.54%	73.32	****
2012	0.0008	0.6578 ****	0.4963 ****	0.1963 ****	-0.2141 ****	-1.0463	0.0122	-0.0250	0.0022	-0.0084	55.56%	37.12	****
2013[A]	-0.0013	0.7839 ****	0.4106 ****	0.1390 **	-0.0663	0.7960	0.0075	0.0259	0.0016	0.0031	57.85%	20.52	****
Mean:	-0.0005	0.5054	0.4060	0.1116	-0.0192	0.3168	0.0138	-0.0006	0.0012	-0.0017	52.92%		

[A] Due to rebalancing in June, data contains six months of observations.

Table D.11: Inter-Temporal Analysis of Big utilities Portfolio using the Local AFFM

This table presents conditional annual local AFFM, estimated on a year-by-year basis using Newey-West HAC standard errors between 1996 and 2013. The value-weighted returns of the big utility portfolio ($\boldsymbol{R_{big}}$) is used as the dependent variable. The nine risk factors include: market premium ($\boldsymbol{R_m}$), local size premium ($LSMB$), local value premium ($LHML$), local momentum premium ($LUMD$), term premium ($\boldsymbol{R_{tp}}$), oil risk (R_o), coal risk (R_c), natural gas risk (R_g) and carbon risk (R_{co2}). The intercept and error term is denoted α_i and e, respectively. A ****, ***, ** or * denotes significance at 0.1%, 1%, 5% or 10%, respectively. The specification used is:

$$\boldsymbol{R_{big}} = \alpha_i + b_i\boldsymbol{R}_m + s_iLSMB + h_iLHML + m_iLUMD + tp_i\boldsymbol{R}_{tp} + o_iR_o + c_iR_{co} + g_iR_g + co2_iR_{co2} + e$$

Year	α_i	b_i	s_i	h_i	m_i	tp_i	o_i	c_i	g_i	$co2_i$	$\boldsymbol{adj.R^2}$	$\boldsymbol{F =}$	Sig.
1996[A]	0.0000	0.5247 ****	-0.5246 ****	0.0578	0.0801	0.4965 **	-0.0184	-0.0410	-0.0082		75.33%	51.01	****
1997	0.0001	0.5850 ****	-0.3756 ****	0.0448	0.1692 ****	-0.0563	0.0114	-0.0199	0.0078		80.57%	135.73	****
1998	0.0003	0.5018 ****	-0.3889 ****	0.0004	-0.0388	0.0544	0.0113	-0.0846 ****	0.0006		78.21%	117.67	****
1999	-0.0003	0.3334 ****	-0.6829 ****	0.0282	-0.0116	0.0240	-0.0075	0.0328 ***	-0.0014		81.78%	146.85	****
2000	0.0006	0.2307 ****	-0.4938 ****	-0.0067	-0.0062	-0.4277	0.0030	0.0202	-0.0007		48.25%	31.18	****
2001	0.0003	0.3987 ****	-0.4062 ****	-0.0870	-0.0298	0.1759	0.0250 *	-0.0196	0.0055		68.30%	71.03	****
2002	0.0001	0.5086 ****	-0.3711 ****	0.0145	-0.0566 *	-0.1639	-0.0297	0.0075	0.0032		85.49%	192.50	****
2003	0.0004 *	0.4729 ****	-0.4135 ****	-0.1636 ****	-0.0915 **	0.2900	-0.0048	-0.0739 **	-0.0024		85.36%	190.52	****
2004	0.0008 ****	0.5547 ****	-0.2598 ****	-0.0764 **	0.0711	0.0324	0.0047	-0.0242	0.0038		67.38%	68.40	****
2005	0.0004	0.8422 ****	-0.1667 ****	-0.1208 ****	0.0751	0.1230	-0.0093	-0.0206	-0.0004		62.91%	55.92	****
2006	0.0005 **	0.7600 ****	-0.1781 ****	-0.0899 **	0.0579	0.1225	0.0529 ***	-0.0052	0.0022	0.0090 **	71.64%	73.70	****
2007	0.0006 *	0.6208 ****	-0.2817 ****	-0.0707 **	0.0670	-0.3810	0.0594 **	-0.0085	-0.0041	0.0004 *	67.55%	61.15	****
2008	0.0001	0.6700 ****	-0.5130 ****	-0.3998 ****	0.0015	0.1152	0.0211	-0.0525 **	0.0235 *	-0.0033	85.83%	176.65	****
2009	0.0001	0.5777 ****	-0.4738 ****	-0.2701 ****	-0.1032 **	-0.3213	0.0181	0.0299	-0.0050	0.0022	79.15%	110.69	****
2010	-0.0078	0.7606 ****	-0.2786 ****	-0.2027 ****	-0.1284 ****	4.2559	0.0397 **	-0.0464 **	0.0067	-0.0084	85.68%	173.81	****
2011	0.0000	0.8261 ****	-0.3756 ****	0.0762	-0.0753 **	-0.1603	0.0229	-0.0079	0.0069	0.0070	84.95%	163.44	****
2012	-0.0001	0.7355 ****	-0.2354 ****	0.1737 ****	-0.1977 ****	-0.0210	-0.0206	-0.0187	-0.0183	0.0133	74.95%	87.44	****
2013[A]	-0.0020	0.7301 ****	-0.3212 ****	0.1598 ***	-0.1971 ***	1.0855	-0.0399	-0.0079	-0.0307	0.0044	72.92%	39.30	****
Mean:	-0.0003	0.5907	-0.3745	-0.0518	-0.0230	0.2913	0.0077	-0.0189	-0.0006	0.0031	75.35%		

[A] Due to rebalancing in June, data contains six months of observations.

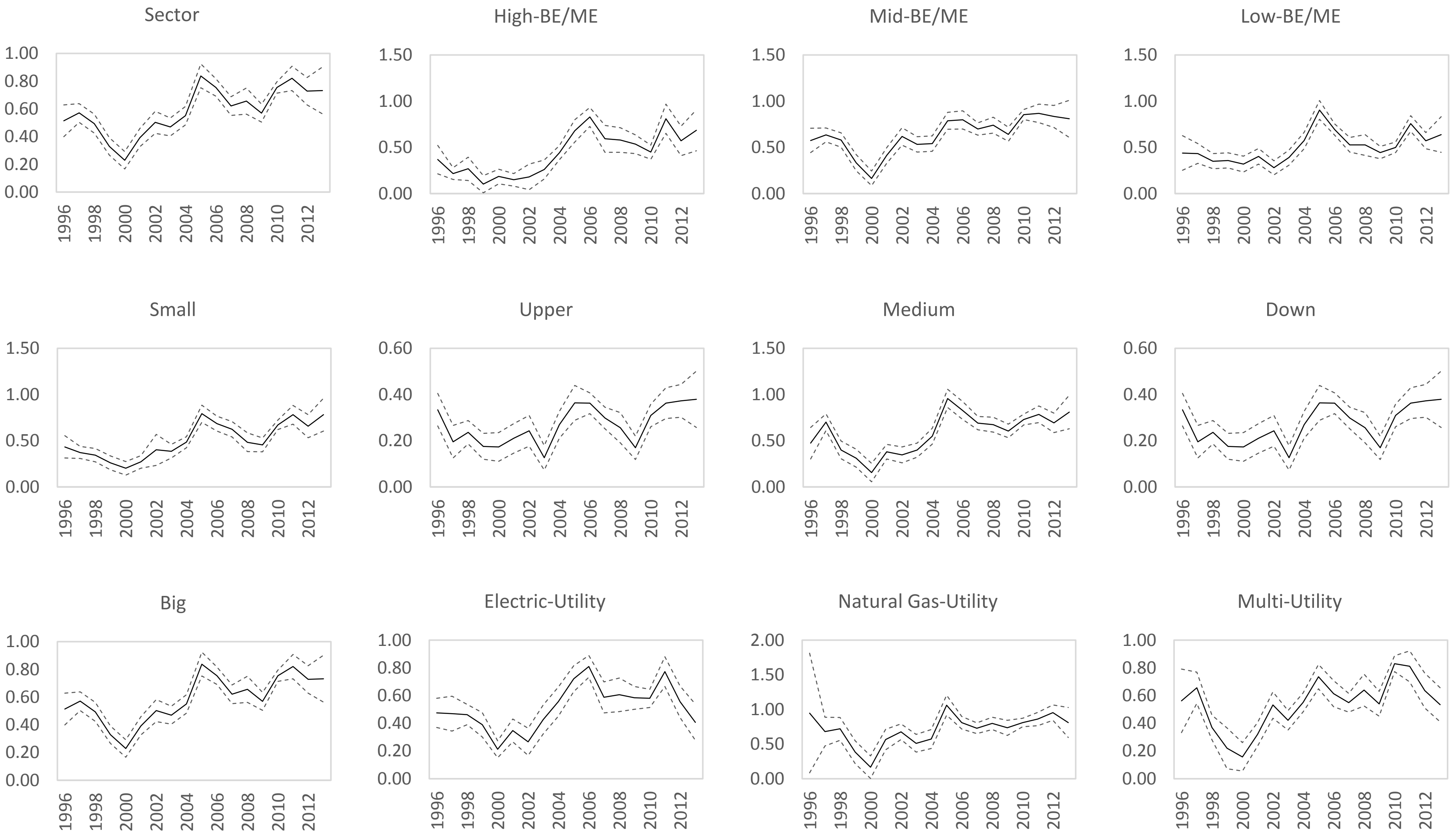


FIGURE D.1: MARKET FACTOR COEFFICIENTS AND 95% CONFIDENCE INTERVALS

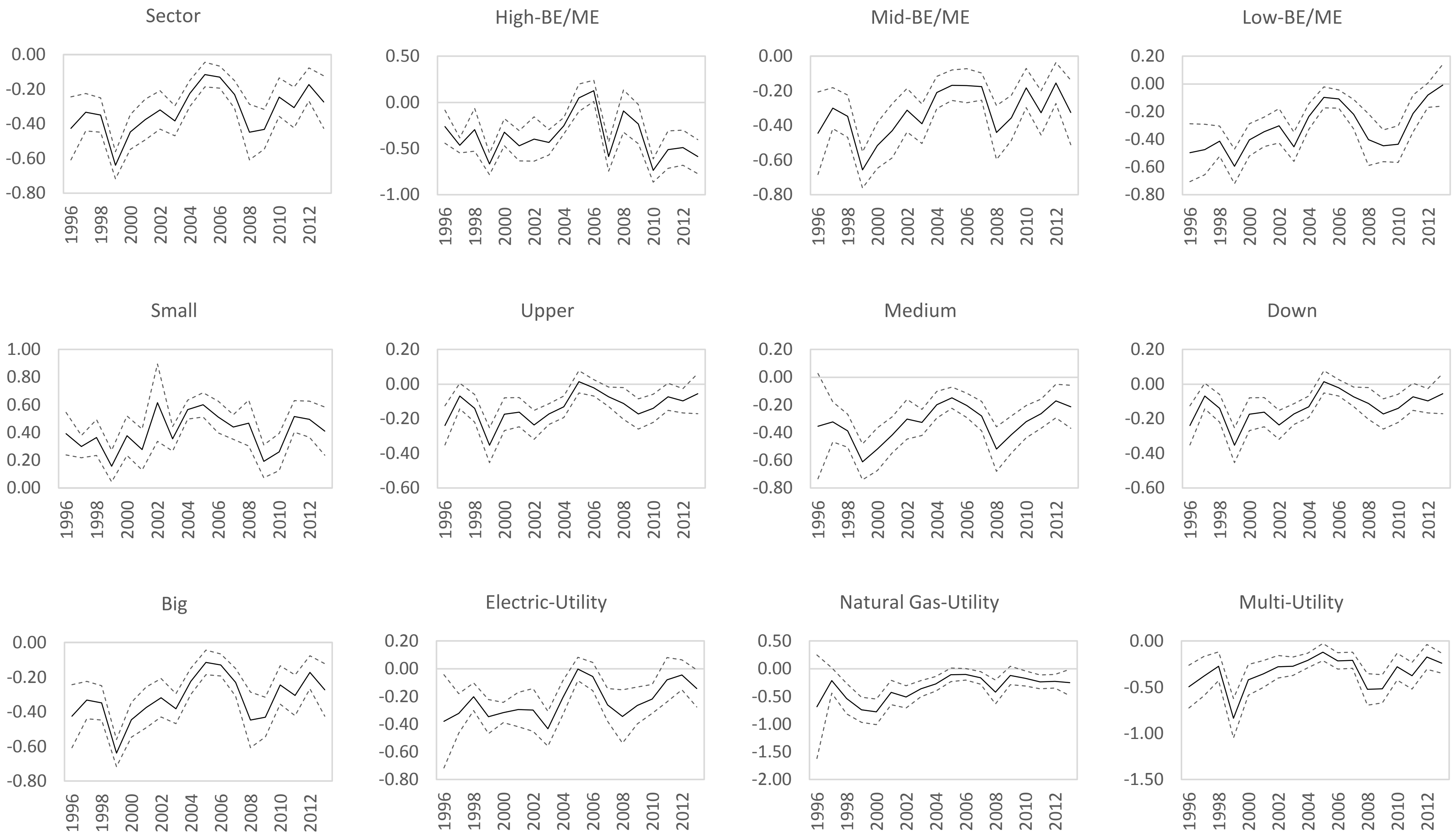


FIGURE D.2: LOCAL SMB COEFFICIENTS AND 95% CONFIDENCE INTERVALS

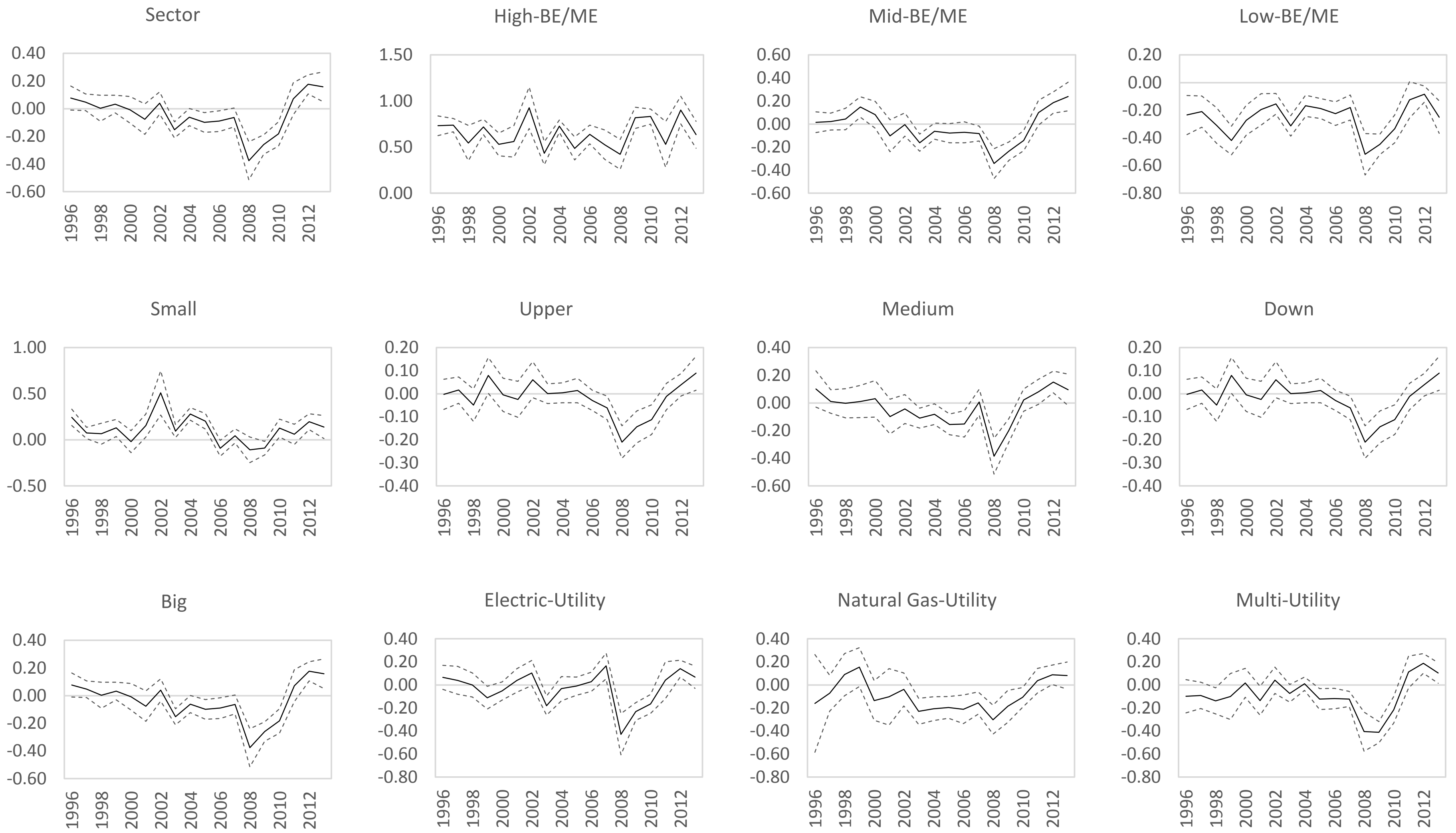


Figure D.3: Local HML Coefficients and 95% confidence intervals

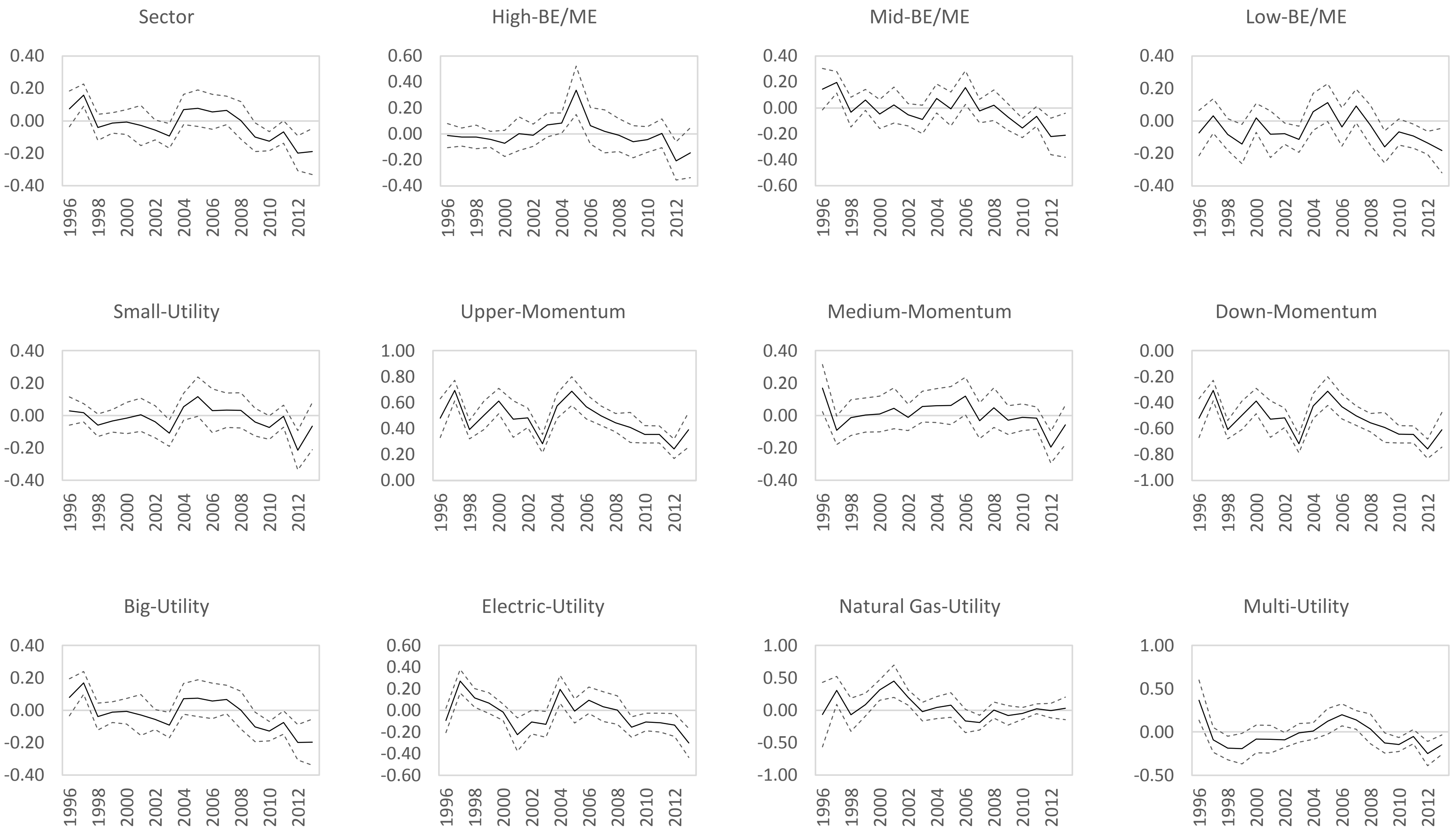


FIGURE D.4: LOCAL UMD COEFFICIENTS AND 95% CONFIDENCE INTERVALS

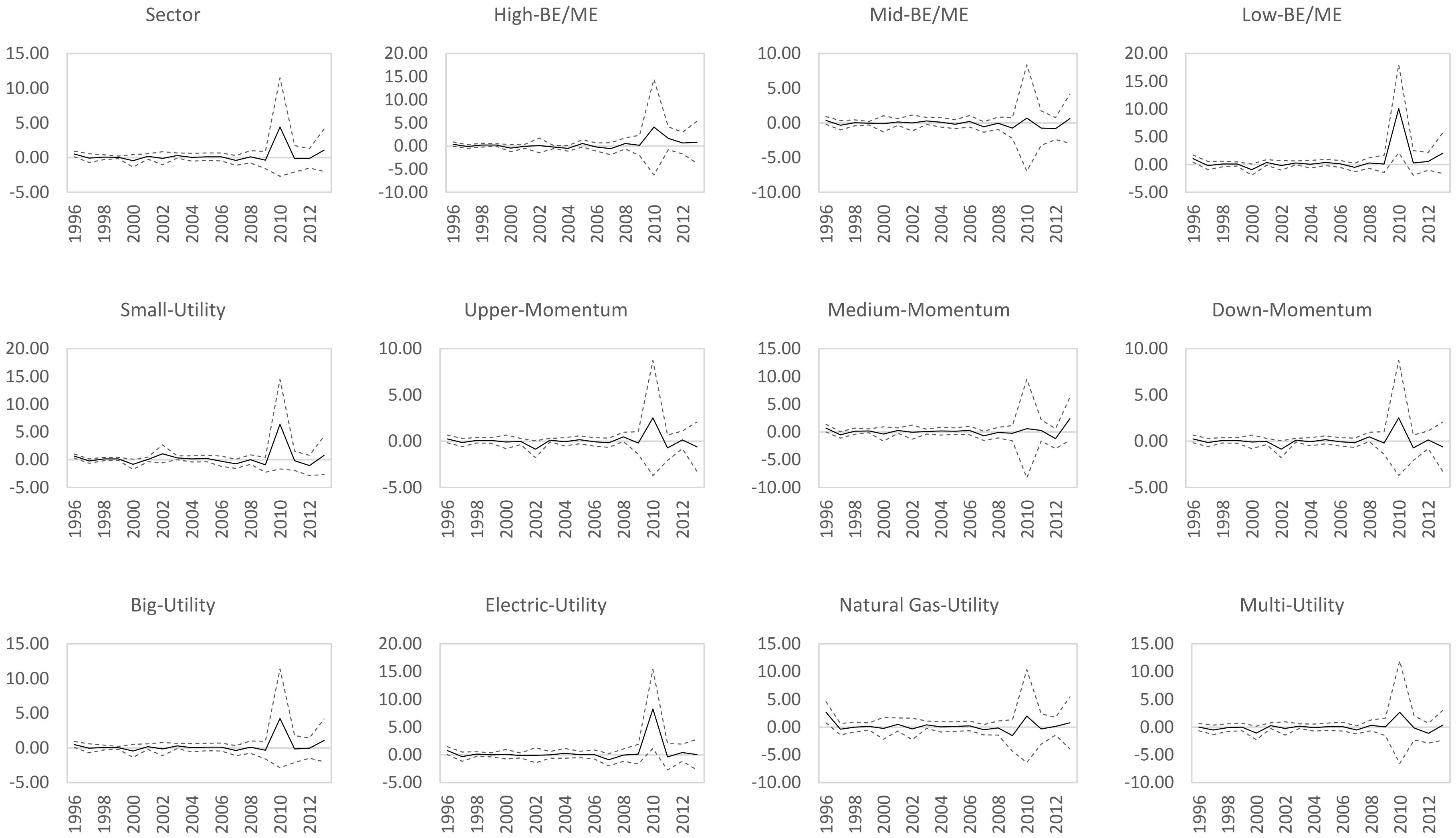


FIGURE D.5: TERM PREMIUM COEFFICIENTS AND 95% CONFIDENCE INTERVALS

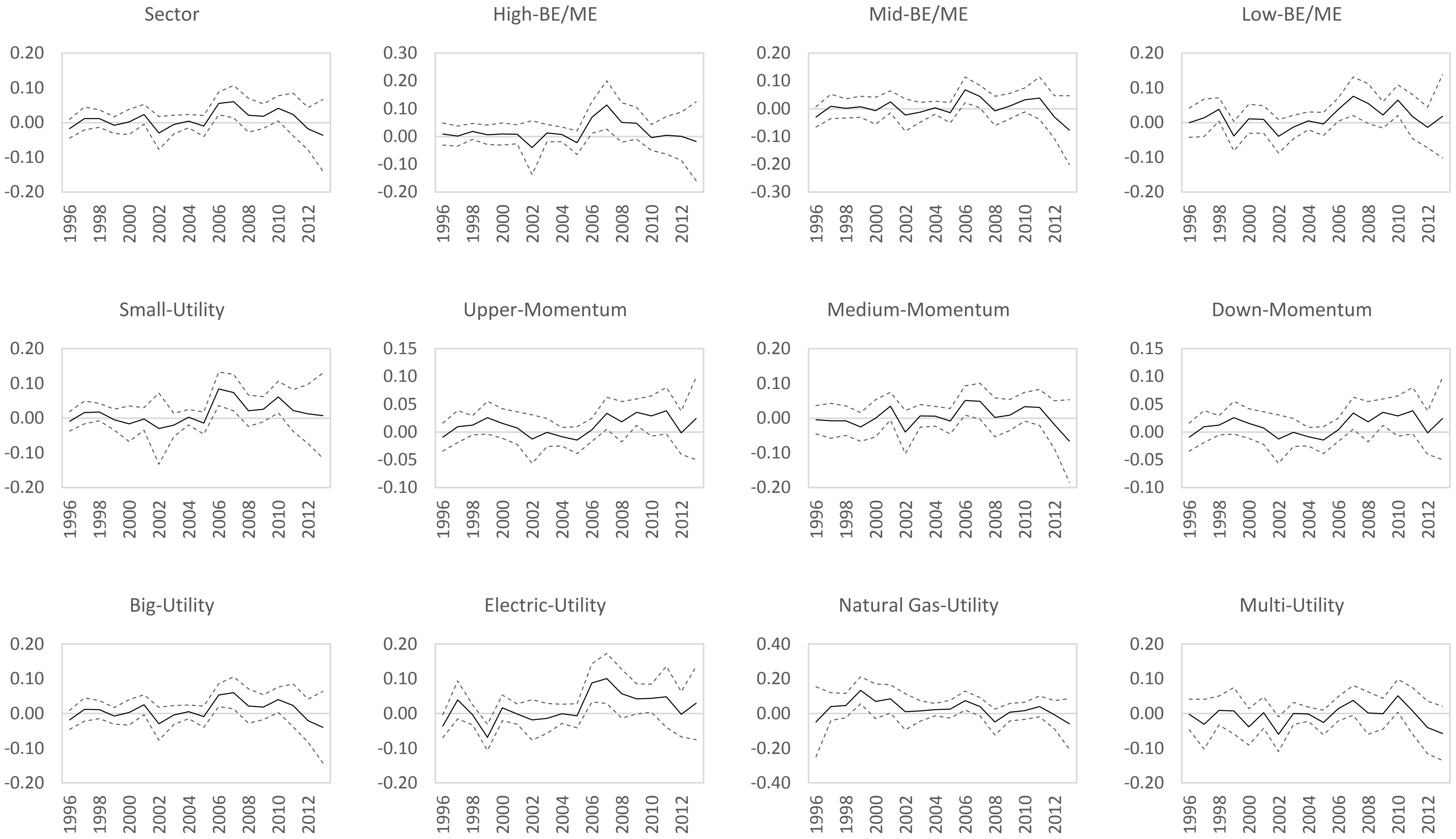


FIGURE D.6: OIL COEFFICIENTS AND 95% CONFIDENCE INTERVALS

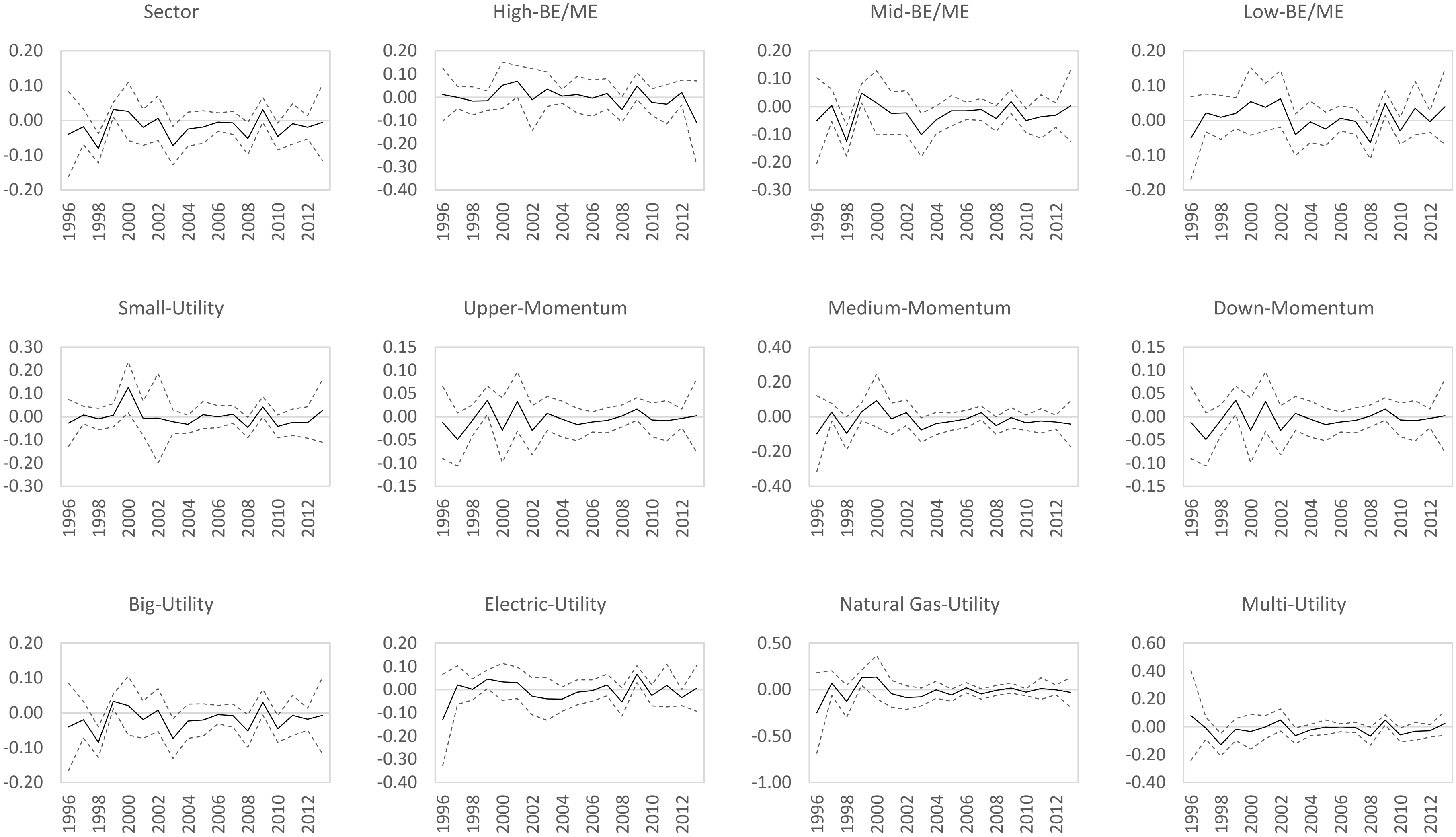


FIGURE D.7: COAL COEFFICIENTS AND 95% CONFIDENCE INTERVALS

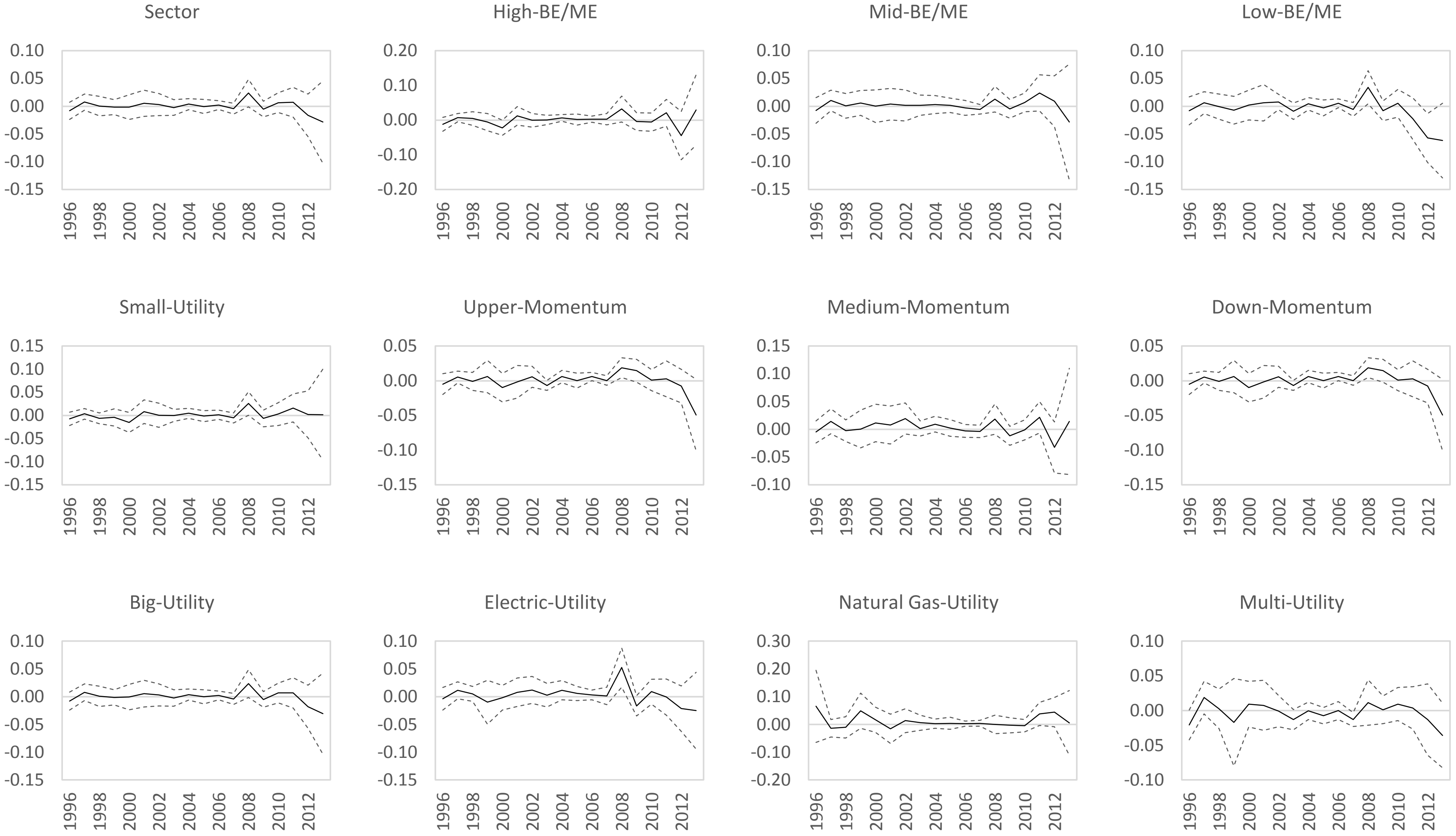


Figure D.8: Gas Coefficients and 95% confidence intervals

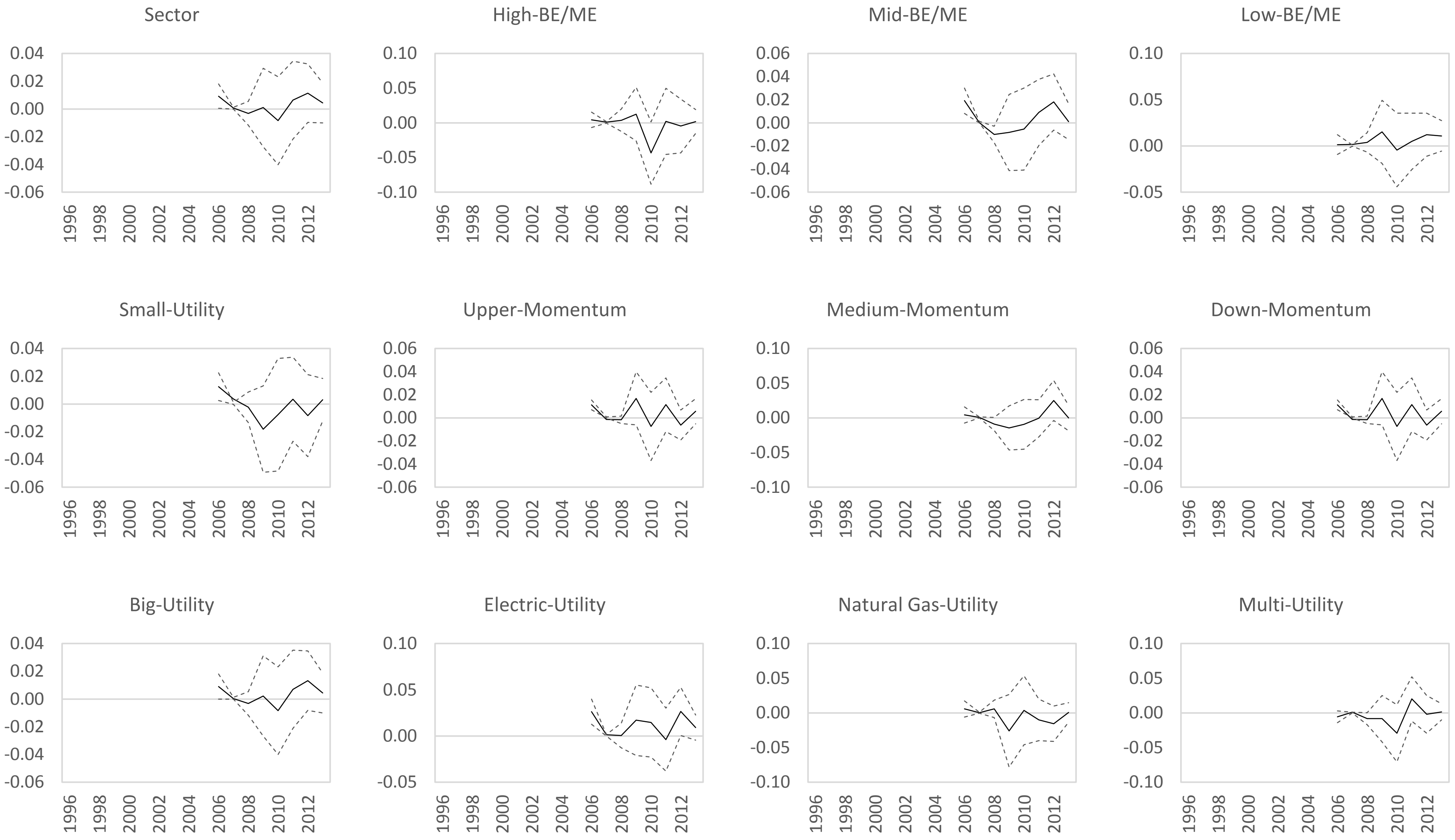


FIGURE D.9: CARBON COEFFICIENTS AND 95% CONFIDENCE INTERVALS

Appendix E. THE FRACTION OF VARIANCE UNEXPLAINED

Section 5.4.2.4 of Chapter 5 showed that the residuals of the unconditional regression captured some of the changing relationship between the average returns in the energy sector and the risk premia. The purpose of this appendix is to demonstrate, algebraically, that at least some of the fraction of variance unexplained (FVU) by the unconditional local AFFM regression can be explained by allowing the relationship between average returns and risk premia to vary over time. This is because the assumption of parameter stability the intercept term of the model, as well as the risk premiums, to be the same across all companies (Chan et al., 1985). This implicitly assumes that the coefficient is also constant across time. Therefore, any violation of the pricing equation, deviations from predicted values, will be absorbed by the residuals. The preceding proposition can be expressed algebraically. Consider a standard OLS regression:

$$y_t = \alpha + \beta x_t + e_t \tag{E.1}$$

where y_t denotes the dependent variable, α denotes the intercept, β denotes the slope with the risk factor, x_t denotes the risk factor and e_t denoes the error term. The parameters α and β are assumed to be stable. The error term captures the shift in risk parameters over partition H so as

$$e_t = \mu_t - \Delta\alpha_H - \Delta\beta_H, \tag{E.2}$$

where $\Delta\alpha_H$ nd $\Delta\beta_H$ represent the shift in the intercept and risk parameter over the structural break, respectively, and μ_t represents the true firm-specific returns. Substituting (E.2) into (E.1) gives:

$$y_t = \alpha + \beta x_t + \mu_t - \Delta\alpha_H - \Delta\beta_H, \tag{E.3}$$

factorised as

$$y_t = \alpha(1 - \Delta\alpha_H) + \beta(1 - \Delta\beta_H)x_t + \mu_t. \tag{E.4}$$

Coefficients α and β are the estimated from the unconditional regression (Table 5.5), while coefficients $\Delta\alpha_H$ and $\Delta\beta_H$ are the estimated shifts in the sequential break point test of the unconditional residuals (Table 5.12). The true firm-specific component of Equation (E.4), denoted are μ_t are the residuals shown in Figure 5.7, Plot (3B). The best method to capture the true firm-specific component of returns is to allow the intercept and slopes to vary during structural breaks. Further, the benefit of estimating sequential break points from the unconditional residuals is that the test is performed relative to the long-term risk parameters. That is, the coefficients and t-statistics in Table 5.12 test whether the parameter shift(s) during the structural break, $\Delta\alpha_H$ and $\Delta\beta_H$, are statistically different from zero, where zero represents no change to the full-period coefficients, α and β. In doing so, the test is better able to detect changes in price risk. For example, natural gas risk becomes statistically significant between April 2009 and January 2011. This coincides a rapid increase in natural gas prices following a period of relatively cheap gas (Plot H, Figure 4.3). This sudden increase in natural gas prices negatively impacted the energy sector.

How can we deduce whether the sequential break point test on the residuals capture the variation of returns missed by the unconditional regression? This can be demonstrated by solving goodness of fit equation: the R^2. The standard R^2 specification is:

$$R^2 = 1 - \frac{SS_{res}}{SS_{tot}}, \tag{E.5}$$

where SS_{tot} is the total sum of squares and SS_{res} denotes the sum of squared residuals. Of interest is SS_{res}/SS_{tot}, which is the unexplained variance of the residuals relative to the total variance – denoted the Fraction of Variance Unexplained (FVU). If the partial break point tests are able to capture a greater proportion of this FVU, decreasing the SS_{res}, then there should be an associated increase in R^2. Specifically, let FVU_A denote the fraction of variance unexplained for the unconditional model, and FVU_B denote the fraction of variance unexplained for the sequential break point regression. Divide FVU_B of the break point regression by FVU_A of the unconditional model to find the fraction of unexplained variance by both models, FVU_C. Subtract FVU_C from 1 to find the coefficient of determination for the sequential break point regression on the residuals:

$$R_C^2 = 1 - \frac{FVU_B}{FVU_A} \equiv 1 - \frac{\left(\frac{SS_{res,B}}{SS_{tot}}\right)}{\left(\frac{SS_{res,A}}{SS_{tot}}\right)} \equiv 1 - \frac{SS_{res,B}}{SS_{res,A}} \tag{E.6}$$

The R_C^2 represents the goodness of fit for the sequential break point regression on the unconditional residuals. That is, the test of the residuals explains a proportion of the previously unexplained variance equal to R_C^2. This can be adapted for adjusted R^2 values, such as those provided in this thesis, where adjusted R^2 is calculated as:

$$adj.R^2 = 1 - (1 - R^2)\left(\frac{N-1}{N-k}\right) \tag{E.7}$$

where N equals the number of observations and k equals the number of parameters tested. Similar to Equation (E.6), Equation (E.7) is solved to show that the fraction of variance unexplained by both models can be calculated as:

$$adj.FVU_C = \frac{adj.FVU_B}{adj.FVU_A} \equiv \frac{(1 - R_B^2)\left(\frac{N-1}{N-k_B}\right)}{(1 - R_A^2)\left(\frac{N-1}{N-k_A}\right)}, \tag{E.8}$$

while the adjusted R_c^2 is simply $1 - adj.FVU_C$. Although Chapter 5 reports adjusted R^2, the unadjusted $R_A^2 = 0.7282$ for Table 5.5, while the unadjusted $R_B^2 = 0.8077$ for Table 5.10 (omitted for brevity); $N = 4435$, the number of parameters[76] are equal to $k_b = 81$ and $k_A = 8$. Substituting the values into Equation (E.8), the $adj.FVU_B = 0.1958$ and $adj.FVU_A = 0.2722$, which results in $adj.FVU_C = 0.7193$; therefore the $adj.R_c^2$ of the sequential break point regression on the unconditional residuals is expected to be $1 - 0.7193 = 0.2807$ or 28.07%. Note, the small differences between the manual calculations and that adjusted R^2 provided in Table 5.12 (27.95%) is likely due to rounding error and some inference on the number of parameters for k_b, however, the value is reasonably accurate.

E.1. Robustness Check – January Seasonals

January seasonals is documented by Keim (1983), who finds that daily returns during the month of January tend to be abnormally high in relation to the remainder of the year. Further, the effect seems to be related to size, with small firms expected to produce abnormally high returns relative to big firms. In line with the robustness test of Fama and French (1993), this section examines the presence of January seasonals in the energy portfolio returns, local stock market risk factors, term premium, stock market risk factors and the three residuals extracted in Section 5.4.2.4.

OLS regressions are implemented on the returns of the 12 energy sector portfolios, risk factors and the various measures of regression residuals – discussed in details shortly in Section 5.4.2.4. Following Fama and French (1993), a mean equation is specified as an intercept and a dummy variable, which takes the value of 1 during January and zero otherwise. The intercept represents the average return over non-January months, while the slope of the dummy measures the difference between average returns in non-January months and the average returns in January. The results and model specification are shown in Table E.1.

Overall, the January seasonals are mostly insignificant. The January dummies are insignificant for all 12 energy profiles. The local SMB factor shows some impact of January seasonals, congruent with Keim (1983) and Fama and French (1993). The spread in average returns between the small and big energy utilities widens in January, but the adjusted R^2 is small (0.14%). Similar to Fama and French (1993), the January seasonals in the risk factors would have largely absorbed any seasonals in the stock returns – if present. Natural gas shows

---

[76] The parameters for the unconditional local AFFM, k_A, is the eight risk factors. For the sequential break point regression, the intercept and eight risk factors are allowed to vary across all partitions. The model detects nine separate partitions, therefore $k_b = 9 \times 9 = 81$ parameters.

some January seasonals, however natural gas was mostly insignificant in the empirical analyses. Finally, no January seasonals were detected in any residual calculations.

TABLE E.1: TESTS FOR JANUARY SEASONALS

Test for January seasonals in stock returns, risk factors, and residuals between 01/07/1996 and 28/06/2013. The mean equation is specified as:

$$r_t = \alpha_i + d_i JanDummy + e_t$$

Portfolios	α_i		d_i		$\boldsymbol{Adj.R^2}$	$\boldsymbol{F =}$	$\boldsymbol{p}$
Energy Sector	0.0000		-0.0003		-0.02%	0.19	
High-BE/ME	0.0001		-0.0002		-0.02%	0.08	
Mid-BE/ME	0.0000		-0.0002		-0.02%	0.09	
Low-BE/ME	-0.0001		-0.0006		0.00%	1.05	
Upper momentum	0.0003	***	0.0001		-0.02%	0.14	
Medium momentum	0.0001		-0.0004		-0.01%	0.35	
Down momentum	0.0000		-0.0006		0.01%	1.33	
Electricity utilities	0.0001		-0.0001		-0.02%	0.01	
Natural gas utilities	0.0002		-0.0004		-0.02%	0.21	
Multi-utilities	0.0001		-0.0006		-0.01%	0.75	
Small utilities	0.0001		0.0005		0.00%	0.91	
Big utilities	0.0000		-0.0003		-0.02%	0.24	
Risk Factors							
$\boldsymbol{R_{m,t}}$	0.0000		-0.0001		-0.02%	0.02	
$LSMB_t$	0.0002	*	0.0012	***	0.14%	7.18	***
$LHML_t$	0.0002		0.0001		-0.02%	0.03	
$LUMD_t$	0.0003		0.0007		0.01%	1.66	
$\boldsymbol{R_{tp,t}}$	0.0003		0.0000		-0.02%	0.32	
$R_{o,t}$	0.0003		0.0007		-0.01%	0.48	
$R_{c,t}$	0.0001		0.0009		0.02%	1.67	
$R_{g,t}$	0.0011	**	-0.0077	****	0.31%	14.61	****
Residuals							
Unconditional local AFFM regression	0.0000		0.0003		-0.01%	0.73	
Conditional annual local AFFM regressions	0.0000		0.0002		0.00%	0.83	
Local AFFM break point regression	0.0000		0.0003		0.01%	1.35	

Appendix F. EVENT STUDY STATA CODE

The following is an example of the *STATA* code used to implement the event study approach. The general framework of the code is extracted from the method outlined by Princeton University (2008). Modifications are made to allow the code to 1) loop over all events and the four restructuring streams, 2) loop over the 12 energy portfolios, 3) calculate CAARs through time, 4) test CAARs across eight event windows and 5) format data for export and storage. The results are qualitatively comparable to those obtained using *Event Study Metrics* – an event study software package. *Event Study Metrics* could not be used because the software limits the list of variables which can be used to estimate normal performance; the four-factor model was the most comprehensive model available. Further, *STATA* lacks a pre-written code to conduct the multivariate event study.

```
*** START ***

* DATA PREPARATION.
* Uses two separate datafiles: eventdates and stockdata.

* Analysis loops over all events and four restructuring streams.
forvalues k=1(1)5 {
*Opens record log.
. log using "C:\Users\Dan Tulloch\Documents\Stata\Event Study\Log\Log`k'.smcl", replace
* Analysis loops over all twelve energy utility portfolios.
forvalues n=1(1)12 {
use "C:\Users\Dan Tulloch\Documents\Stata\Event Study\Event Dates\eventdates`k'.dta", clear
by company_id: gen eventcount=_N
by company_id: keep if _n==1
sort company_id
local no_of_events = _N
display `no_of_events'
keep company_id eventcount
save "C:\Users\Dan Tulloch\Documents\Stata\Event Study\eventcount`n'.dta", replace
* Merge the eventcount data with stockdata, ensuring both files have eligible observations.
use "C:\Users\Dan Tulloch\Documents\Stata\Event Study\Returns Data\stockdata`n'.dta", clear
sort company_id
merge company_id using "C:\Users\Dan Tulloch\Documents\Stata\Event Study\eventcount`n'.dta"
tab _merge
keep if _merge==3
drop _merge
* 'expand' command creates duplicate observations - accommodates multiple events per
portfolio.
expand eventcount
* Indicates which 'set' of observations within the company each observation belongs to.
drop eventcount
sort company_id date
by company_id date: gen set=_n
sort company_id set
save "C:\Users\Dan Tulloch\Documents\Stata\Event Study\stockdata2`n'.dta", replace
* Creates a matching set variable to identify the different event dates within each portfolio.
use "C:\Users\Dan Tulloch\Documents\Stata\Event Study\Event Dates\eventdates`k'.dta", clear
by company_id: gen set=_n
sort company_id set
save "C:\Users\Dan Tulloch\Documents\Stata\Event Study\eventdates2`n'.dta", replace
use "C:\Users\Dan Tulloch\Documents\Stata\Event Study\stockdata2`n'.dta", clear
merge company_id set using "C:\Users\Dan Tulloch\Documents\Stata\Event
Study\eventdates2`n'.dta"
tab _merge
* Examines and drops portfolios which have missing information surrounding event dates.
list company_id if _merge==2
keep if _merge==3
drop _merge
* Creates a new variable that groups company_id and set so that each has a unique identifier
to use in future analysis.
```

```
egen group_id = group(company_id set)
egen max_no_of_groups = max(group_id)
local max_groups =  max_no_of_groups
display `max_groups'

* CLEANING THE DATA AND DEFINING THE EVENT AND ESTIMATION WINDOWS.
* Creates a variable (dif) which counts the number of days between the observation and the
event date.
sort group_id date
by group_id: gen datenum=_n
by group_id: gen target=datenum if date==event_date
egen td=min(target), by(group_id)
drop target
gen dif=datenum-td
* Creates a variable with the event date.
* Ensures a minimum number of observations before and after the event date, as well as the
minimum number of observations before the event window for the estimation window.
* For this analysis: event window is 41 days, estimation window is 100 days.
by group_id: gen event_window=1 if dif>=-20 & dif<=20
egen count_event_obs=count(event_window), by(group_id)
by group_id: gen estimation_window=1 if dif<=-21 & dif>=-120
egen count_est_obs=count(estimation_window), by(group_id)
replace event_window=0 if event_window==.
replace estimation_window=0 if estimation_window==.

* Determines which companies do not have a sufficient number of observations.
tab group_id if count_event_obs<41
tab group_id if count_est_obs<100

* ESTIMATING NORMAL PERFORMANCE USING THE AUGMENTED FOUR-FACTOR MODEL (AFFM).
* The command loops over each event, running a regression in each estimation window, and uses
estimated coefficients and intercept to predict expected return/normal performance.
* Estimates are stored ready for export.
set more off
gen predicted_return=.
egen id = group(group_id)
forvalues i=1(1)`max_groups' {
l id group_id if id==`i' & dif==0
reg ret stoxx SMB HML UMD term oil coal gas if id==`i' & estimation_window==1
eststo AFFM`i'
predict p if id==`i'
replace predicted_return = p if id==`i' & dif<=20 & dif>=-120
drop p
}

* Exports estimates.
esttab AFFM* using "C:\Users\Dan Tulloch\Documents\Stata\Event Study\Output\normal
parameters`k'.csv" , b(4) ar2(4) plain not noobs append
eststo clear

* CALCULATING ABNORMAL RETURN AND CUMULATIVE ABNORMAL RETURN.
* Generates abnormal return.
sort id date
gen abnormal_return = ret-predicted_return if dif<=20 & dif>=-120
by id: egen cumulative_abnormal_return = sum(abnormal_return)
save "C:\Users\Dan Tulloch\Documents\Stata\Event Study\stockdata2`n'.dta", replace
}

* TESTING FOR SIGNIFICANCE
forvalues n=1(1)12 {
use "C:\Users\Dan Tulloch\Documents\Stata\Event Study\stockdata2`n'.dta", clear

* Calculates and uses Std Dev of CAAR during estimation window (-120,-21) for time-series t-
test.
sort id date

* Tests full event window (-20,20).
by id: egen cumulative_return2020 = sum(abnormal_return) if dif<=20 & dif>=-20
reg  cumulative_return2020 if dif==0, robust
eststo CR2020

* Tests short event windows (-20,-1), (-10,-1), (1,10) and (1,20).
by id: egen cumulative_return201 = sum(abnormal_return) if dif<=-1 & dif>=-20
reg  cumulative_return201 if dif==-1, robust
eststo CR201
by id: egen cumulative_return101 = sum(abnormal_return) if dif<=-1 & dif>=-10
reg  cumulative_return101 if dif==-1, robust
eststo CR101
by id: egen cumulative_return110 = sum(abnormal_return) if dif<=10 & dif>=1
```

```
reg  cumulative_return110 if dif==1, robust
eststo CR110
by id: egen cumulative_return120 = sum(abnormal_return) if dif<=20 & dif>=1
reg  cumulative_return120 if dif==1, robust
eststo CR120

* Tests narrow event windows (0,0), (-1,1) and (-2,2).
by id: egen cumulative_return0 = sum(abnormal_return) if dif==0
reg  cumulative_return0 if dif==0, robust
eststo CR0
by id: egen cumulative_return11 = sum(abnormal_return) if dif<=1 & dif>=-1
reg  cumulative_return11 if dif==0, robust
eststo CR11
by id: egen cumulative_return22 = sum(abnormal_return) if dif<=2 & dif>=-2
reg  cumulative_return22 if dif==0, robust
eststo CR22

* Exports estimates.
esttab using "C:\Users\Dan Tulloch\Documents\Stata\Event Study\Output\cumulativetest`k'.csv",
b(4) plain noobs nostar append p(4)
save "C:\Users\Dan Tulloch\Documents\Stata\Event Study\stockdata2`n'.dta", replace

* Calculates cumulative returns through time and estimates std. dev. of CAAR for t-test.
collapse abnormal_return, by(dif)
gen cumulative_return=.
replace cumulative_return = abnormal_return if dif==-120
keep if dif<=20 & dif>=-120
tsset dif
replace cumulative_return = L.cumulative_return + abnormal_return if dif<=-21 & dif>=-119
egen car_sd = sd(cumulative_return) if dif<=-21 & dif>=-120
scalar sd = car_sd
display sd

* Truncates data for CAAR tests across varying event windows.
keep if dif<=20 & dif>=-20
drop cumulative_return
drop car_sd

* Calculates cumulative returns through time with time-series t-stats for descriptive results.
gen cumulative_return=.
replace cumulative_return = abnormal_return if dif==-20
replace cumulative_return = L.cumulative_return + abnormal_return if dif<=20 & dif>=-19
gen tstat = (cumulative_return/sd)
scalar drop _all

* Exports results
save "C:\Users\Dan Tulloch\Documents\Stata\Event Study\Output\Cumulative Returns\cumulative
returns`n'.dta", replace
}

* Consolidates multiple results from multiple files into one user-friendly file.
* Prepares file CAARs for data import.
use "C:\Users\Dan Tulloch\Documents\Stata\Event Study\Output\DND cumulative returns through
time.dta", clear
keep dif
save "C:\Users\Dan Tulloch\Documents\Stata\Event Study\Output\CAAR through time`k'.dta",
replace

* Joins cumulative returns through time, for all twelve portfolios, into a single file.
forvalues n=1(1)12 {
use "C:\Users\Dan Tulloch\Documents\Stata\Event Study\Output\Cumulative Returns\cumulative
returns`n'.dta", clear
keep dif cumulative_return tstat
rename cumulative_return cumulative_return`n'
rename tstat tstat`n'
joinby dif using "C:\Users\Dan Tulloch\Documents\Stata\Event Study\Output\CAAR through
time`k'.dta"
save "C:\Users\Dan Tulloch\Documents\Stata\Event Study\Output\CAAR through time`k'.dta",
replace
}
* Sorts data sequentially - simplifies Excel import.
use "C:\Users\Dan Tulloch\Documents\Stata\Event Study\Output\CAAR through time`k'.dta", clear
order dif cumulative_return* tstat*, seq
save "C:\Users\Dan Tulloch\Documents\Stata\Event Study\Output\CAAR through time`k'.dta",
replace

clear

log close
```

```
* Copy files to new location.

copy "C:\Users\Dan Tulloch\Documents\Stata\Event Study\Event Dates\eventdates`k'.dta"
"C:\Users\Dan Tulloch\Desktop\Event Study\temp\Event Dates\eventdates`k'.dta"
copy "C:\Users\Dan Tulloch\Documents\Stata\Event Study\Output\cumulativetest`k'.csv"
"C:\Users\Dan Tulloch\Desktop\Event Study\temp\cumulative tests\cumulative tests`k'.csv"
copy "C:\Users\Dan Tulloch\Documents\Stata\Event Study\Output\normal parameters`k'.csv"
"C:\Users\Dan Tulloch\Desktop\Event Study\temp\normal parameters\normalparameters`k'.csv"
copy "C:\Users\Dan Tulloch\Documents\Stata\Event Study\Log\Log`k'.smcl" "C:\Users\Dan
Tulloch\Desktop\Event Study\temp\Logs\Log`k'.smcl"
copy "C:\Users\Dan Tulloch\Documents\Stata\Event Study\Output\CAAR through time`k'.dta"
"C:\Users\Dan Tulloch\Desktop\Event Study\temp\cumulative returns through time\CAAR through
time`k'.dta"
erase "C:\Users\Dan Tulloch\Documents\Stata\Event Study\Output\cumulativetest`k'.csv"
erase "C:\Users\Dan Tulloch\Documents\Stata\Event Study\Output\normal parameters`k'.csv"
erase "C:\Users\Dan Tulloch\Documents\Stata\Event Study\Output\CAAR through time`k'.dta"
}
* Clears disk-space by erasing unneccessary files.

forvalues n=1(1)12 {
erase "C:\Users\Dan Tulloch\Documents\Stata\Event Study\eventcount`n'.dta"
erase "C:\Users\Dan Tulloch\Documents\Stata\Event Study\eventdates2`n'.dta"
erase "C:\Users\Dan Tulloch\Documents\Stata\Event Study\stockdata2`n'.dta"
erase "C:\Users\Dan Tulloch\Documents\Stata\Event Study\Output\Cumulative Returns\cumulative
returns`n'.dta"
}

*** END ***
```

Appendix G. ARS SURROUNDING EVENT DATES

TABLE G.1: ARS SURROUNDING THE 1ST POSITION

Panel A presents the Abnormal Returns (ARs) for the 12 energy portfolios over the $(-20{,}20)$ event window. Event days are relative to the announcement of the 1st position. For each portfolio, the t-statistics is calculated as the AR at day t divided by the standard deviation of ARs over the estimation window (day -21 to -121). The t-test examines whether the observed ARs is significant different from zero. A ****, ***, ** or * denotes significance at 0.1%, 1%, 5% or 10%, respectively.

PANEL A: Abnormal Returns

	Portfolios											
Day	**Energy Utilities**	**High-BE/ME**	**Mid-BE/ME**	**Low-BE/ME**	**Upper**	**Medium**	**Down**	**Electric**	**Natural Gas**	**Multi-Utility**	**Small**	**Big**
-20	0.18%*	0.11%	0.28%**	0.05%*	0.06%	0.19%	0.06%	0.03%	0.19%	0.22%**	0.19%	0.19%*
-19	0.13%	0.21%	0.01%	0.18%	0.09%	0.08%	0.09%	0.06%	0.04%	0.12%	0.05%	0.13%
-18	-0.09%	-0.03%	-0.05%	-0.13%	-0.02%	-0.18%	-0.02%	-0.07%	-0.13%	-0.07%	-0.03%	-0.09%
-17	-0.17%*	-0.09%	-0.22%*	-0.07%*	0.00%	-0.27%**	0.00%	-0.16%	-0.14%	-0.15%	-0.22%*	-0.16%
-16	-0.01%	-0.22%*	-0.03%	-0.02%	-0.03%	-0.08%	-0.03%	0.03%	-0.25%	-0.01%	-0.21%*	0.00%
-15	-0.14%	0.12%	-0.28%**	0.01%	-0.12%	-0.24%**	-0.12%	-0.12%	-0.43%**	-0.14%	-0.03%	-0.15%
-14	-0.02%	0.23%*	-0.09%	0.05%	0.00%	0.01%	0.00%	0.13%	-0.24%	-0.04%	0.19%	-0.03%
-13	0.07%	0.15%	0.03%	0.14%	0.12%*	0.06%	0.12%*	0.24%*	-0.23%	-0.01%	0.16%	0.07%
-12	0.08%	0.15%	0.08%	0.01%	0.02%	-0.08%	0.02%	0.06%	-0.07%	0.11%	0.03%	0.08%
-11	-0.09%	0.01%	-0.13%	-0.06%	0.01%	-0.12%	0.01%	0.13%	-0.46%**	-0.11%	-0.14%	-0.09%
-10	-0.12%	-0.21%	-0.17%	-0.11%	-0.04%	-0.17%	-0.04%	0.00%	-0.45%**	-0.02%	-0.19%	-0.12%
-9	0.09%	-0.02%	0.13%	0.01%	-0.03%	0.11%	-0.03%	0.16%	-0.11%	0.08%	0.06%	0.09%
-8	-0.07%	-0.01%	-0.06%	-0.05%	-0.06%	0.04%	-0.06%	-0.03%	-0.16%	0.01%	-0.13%	-0.07%
-7	-0.07%	-0.08%	-0.07%	0.07%	0.02%	-0.04%	0.02%	0.04%	0.22%	-0.20%*	-0.13%	-0.06%
-6	0.04%	0.10%	0.00%	0.08%	-0.06%	0.19%	-0.06%	0.03%	0.05%	0.08%	0.17%	0.03%
-5	-0.07%	0.24%*	-0.21%*	0.11%	-0.06%	-0.16%	-0.06%	-0.17%	0.12%	-0.04%	-0.06%	-0.07%
-4	-0.07%	0.07%	-0.09%	-0.12%	0.00%	-0.06%	0.00%	-0.06%	0.01%	-0.07%	0.04%	-0.08%
-3	-0.06%	-0.13%	0.04%	-0.09%	-0.20%**	-0.10%	-0.20%**	-0.03%	0.09%	-0.02%	-0.04%	-0.06%
-2	-0.14%	-0.18%	-0.04%	-0.35%	-0.04%	-0.24%**	-0.04%	-0.10%	-0.23%	-0.24%**	-0.14%	-0.13%
-1	-0.21%**	-0.02%	-0.34%***	-0.05%**	-0.15%*	-0.23%*	-0.15%*	-0.21%*	-0.19%	-0.10%	-0.20%	-0.21%**
0	-0.08%	-0.22%*	-0.09%	-0.01%	-0.01%	-0.19%	-0.01%	-0.06%	-0.06%	-0.09%	-0.20%	-0.07%
1	-0.12%	0.01%	-0.21%*	0.03%	-0.12%	-0.09%	-0.12%	-0.19%	-0.11%	-0.02%	0.04%	-0.13%
2	0.07%	-0.11%	0.08%	0.09%	0.00%	0.04%	0.00%	0.16%	-0.21%	0.13%	-0.02%	0.07%
3	-0.07%	-0.07%	-0.07%	-0.03%	-0.07%	-0.08%	-0.07%	-0.02%	-0.10%	0.08%	-0.07%	-0.07%
4	0.07%	0.06%	0.13%	-0.05%	0.06%	0.03%	0.06%	0.17%	-0.31%*	0.05%	-0.03%	0.08%
5	-0.06%	0.09%	-0.20%*	0.12%	0.05%	-0.02%	0.05%	-0.07%	-0.15%	-0.05%	0.08%	-0.07%
6	-0.07%	-0.21%	-0.05%	-0.09%	-0.11%	-0.02%	-0.11%	0.00%	0.13%	-0.20%*	-0.05%	-0.07%
7	0.05%	0.03%	-0.01%	0.13%	0.14%*	-0.08%	0.14%*	0.30%**	0.10%	-0.17%	0.15%	0.04%
8	-0.12%	-0.13%	-0.07%	-0.21%	-0.02%	-0.14%	-0.02%	-0.03%	-0.27%	-0.12%	-0.21%*	-0.12%
9	-0.12%	-0.32%**	-0.15%	0.01%	0.01%	-0.12%	0.01%	-0.21%*	-0.19%	-0.03%	-0.13%	-0.12%
10	-0.09%	-0.15%	-0.11%	-0.08%	-0.12%	-0.16%	-0.12%	-0.02%	-0.17%	-0.12%	-0.09%	-0.09%
11	-0.07%	-0.03%	-0.11%	0.01%	-0.08%	0.03%	-0.08%	-0.09%	0.08%	-0.09%	-0.15%	-0.06%
12	-0.05%	-0.25%*	-0.02%	-0.01%	-0.07%	-0.14%	-0.07%	0.04%	-0.38%**	0.04%	-0.12%	-0.05%
13	0.14%	0.25%*	0.06%	0.30%	-0.05%	0.28%**	-0.05%	0.08%	-0.02%	0.19%*	0.09%	0.15%
14	0.01%	-0.07%	-0.01%	0.02%	-0.06%	0.06%	-0.06%	0.13%	0.05%	-0.08%	0.07%	0.00%
15	-0.08%	0.02%	-0.09%	-0.05%	-0.08%	-0.18%	-0.08%	-0.24%**	0.06%	-0.02%	-0.04%	-0.08%
16	-0.11%	-0.05%	-0.14%	-0.11%	0.00%	-0.13%	0.00%	-0.10%	-0.37%**	0.00%	-0.09%	-0.11%
17	-0.05%	0.05%	-0.11%	0.00%	0.01%	-0.11%	0.01%	-0.09%	-0.17%	-0.09%	-0.02%	-0.06%
18	0.12%	0.05%	0.12%	0.17%	0.05%	-0.04%	0.05%	0.19%	-0.03%	0.09%	0.12%	0.12%
19	-0.07%	-0.06%	-0.05%	-0.13%	0.00%	-0.10%	0.00%	0.02%	-0.30%*	-0.09%	-0.21%*	-0.06%
20	0.17%*	0.03%	0.15%	0.23%*	0.10%	0.13%	0.10%	0.19%	0.06%	0.03%	0.13%	0.17%*

Panel B reports the mean estimated coefficients from the local AFFM model in Equation (6.1). The coefficients are estimated in the estimation window prior to all announcements of the 1st position, and the mean coefficient is reported below. As the values below are averages across all events tested, no significance tests are provided. Qualitatively, the mean coefficients below are similar to those reported for the local AFFM in Chapter 5 (Table 5.5). Similar estimates of systematic risk gives greater confidence to the isolation of the unsystematic component in Panel A. Further, the similarity between the coefficients in Panel B and those in Table 5.5 show that nonsynchronous and thin trading have not biased estimated parameters.

PANEL B: Mean Estimated Coefficients from the Local AFFM

	Energy Utilities	**High-BE/ME**	**Mid-BE/ME**	**Low-BE/ME**	**Upper**	**Medium**	**Down**	**Electric**	**Natural Gas**	**Multi-Utility**	**Small**	**Big**
$\bar{b}_i$	0.5975	0.4475	0.6398	0.5252	0.2484	0.5931	0.2484	0.5411	0.7256	0.5320	0.5095	0.6033
$\bar{s}_i$	-0.2934	-0.2748	-0.2940	-0.3071	-0.1171	-0.3179	-0.1171	-0.2273	-0.2959	-0.2816	0.4319	-0.3418
$\bar{h}_i$	-0.1021	0.6349	-0.0931	-0.2780	-0.0340	-0.0956	-0.0340	-0.0784	-0.1637	-0.1046	0.1126	-0.1155
$\bar{m}_i$	-0.0225	0.0080	-0.0014	-0.0574	0.4414	0.0308	-0.5586	-0.0430	0.0478	-0.0102	-0.0300	-0.0215
$\overline{tp}_i$	-0.0379	-0.0256	-0.1191	0.0104	-0.1884	-0.2028	-0.1884	0.0893	0.1602	-0.3357	-0.2640	-0.0179
$\bar{o}_i$	0.0161	0.0134	0.0119	0.0161	0.0117	0.0140	0.0117	0.0181	0.0290	0.0005	0.0123	0.0162
$\bar{c}_i$	-0.0486	0.0160	-0.0631	-0.0277	-0.0101	-0.0477	-0.0101	-0.0486	-0.0642	-0.0344	-0.0069	-0.0508
$\bar{g}_i$	0.0054	0.0074	0.0043	0.0055	0.0022	0.0028	0.0022	0.0114	0.0160	-0.0010	0.0105	0.0049
$\bar{\alpha}_i$	0.0005	0.0004	0.0009	0.0002	0.0008	0.0007	0.0008	0.0005	0.0006	0.0008	0.0011	0.0005
$\overline{\boldsymbol{Adj.R}}$	0.7347	0.6939	0.6703	0.6705	0.6080	0.6283	0.7283	0.5928	0.5564	0.6087	0.5186	0.7429

TABLE G.2: ARs SURROUNDING THE 2ND POSITION

Panel A presents the Abnormal Returns (ARs) for the 12 energy portfolios over the (-20,20) event window. Event days are relative to the announcement of the 1st position. For each portfolio, the t-statistics is calculated as the AR at day t divided by the standard deviation of ARs over the estimation window (day -21 to -121). The t-test examines whether the observed ARs is significant different from zero. A ****, ***, ** or * denotes significance at 0.1%, 1%, 5% or 10%, respectively.

PANEL A: Abnormal Returns

Day	Portfolios											
	Energy Utilities	High-BE/ME	Mid-BE/ME	Low-BE/ME	Upper	Medium	Down	Electric	Natural Gas	Multi-Utility	Small	Big
-20	0.01%	-0.05%	0.08%	-0.09%	0.03%	-0.08%	0.03%	0.14%	0.22%	-0.13%	-0.10%	0.02%
-19	-0.20%**	-0.21%*	-0.25%**	-0.11%**	-0.10%	-0.19%*	-0.10%	-0.20%*	-0.30%**	-0.17%*	-0.27%***	-0.19%**
-18	0.02%	0.16%	0.06%	-0.10%	0.01%	-0.01%	0.01%	0.01%	-0.09%	-0.12%	0.06%	0.02%
-17	-0.11%	-0.19%*	-0.10%	-0.13%	-0.14%**	-0.10%	-0.14%**	-0.27%**	-0.27%*	-0.03%	-0.22%**	-0.10%
-16	-0.18%**	-0.17%	-0.20%**	-0.14%**	-0.23%****	-0.12%	-0.23%****	-0.17%	-0.22%	-0.15%	-0.21%**	-0.18%*
-15	-0.07%	-0.12%	-0.03%	-0.02%	0.08%	-0.05%	0.08%	0.03%	-0.47%***	0.14%	-0.22%**	-0.06%
-14	0.00%	-0.16%	0.06%	-0.06%	-0.01%	-0.06%	-0.01%	0.06%	0.07%	-0.04%	0.01%	0.00%
-13	-0.08%	0.04%	-0.07%	-0.10%	-0.07%	-0.07%	-0.07%	-0.13%	-0.12%	-0.08%	-0.01%	-0.08%
-12	0.08%	0.00%	-0.03%	0.24%	0.02%	0.16%	0.02%	0.01%	0.15%	0.06%	0.07%	0.08%
-11	0.07%	-0.09%	0.14%	0.04%	-0.03%	0.18%*	-0.03%	0.00%	0.32%**	0.18%*	0.04%	0.07%
-10	-0.04%	-0.17%	-0.03%	-0.01%	-0.03%	0.05%	-0.03%	-0.10%	0.08%	0.02%	-0.14%	-0.04%
-9	0.01%	0.04%	0.05%	-0.09%	-0.06%	-0.05%	-0.06%	-0.03%	0.14%	-0.18%*	0.10%	0.00%
-8	-0.09%	-0.04%	-0.09%	-0.12%	0.01%	-0.11%	0.01%	-0.27%**	-0.23%	0.07%	-0.06%	-0.10%
-7	-0.13%	-0.21%*	-0.06%	-0.17%	-0.12%*	-0.25%**	-0.12%*	-0.17%	0.11%	-0.19%*	-0.12%	-0.13%
-6	-0.24%**	-0.16%	-0.27%**	-0.15%**	-0.12%*	-0.25%**	-0.12%*	-0.33%***	0.07%	-0.27%***	-0.14%	-0.24%**
-5	-0.05%	0.01%	0.04%	-0.18%	-0.07%	-0.02%	-0.07%	-0.06%	0.01%	-0.02%	-0.08%	-0.05%
-4	0.11%	-0.03%	0.09%	0.13%	0.10%*	0.20%*	0.10%*	0.12%	0.15%	0.10%	0.09%	0.11%
-3	-0.15%*	0.00%	-0.26%**	-0.08%*	0.10%	-0.23%**	0.10%	-0.05%	0.15%	-0.31%***	-0.11%	-0.16%*
-2	-0.10%	-0.06%	-0.10%	-0.13%	-0.06%	-0.11%	-0.06%	-0.02%	-0.32%**	-0.12%	-0.05%	-0.10%
-1	0.06%	-0.01%	0.06%	0.08%	0.05%	-0.03%	0.05%	0.09%	0.07%	0.03%	0.00%	0.07%
0	0.14%	0.25%**	0.15%	0.08%	0.07%	0.12%	0.07%	0.21%*	0.18%	0.05%	0.11%	0.14%
1	-0.07%	-0.08%	-0.03%	-0.14%	-0.01%	-0.05%	-0.01%	-0.12%	-0.05%	0.01%	0.01%	-0.07%
2	-0.28%***	-0.34%***	-0.24%**	-0.34%***	-0.07%	-0.23%**	-0.07%	-0.40%***	-0.33%**	-0.17%*	-0.34%***	-0.27%***
3	0.05%	0.08%	-0.02%	0.20%	0.10%	-0.03%	0.10%	0.21%*	-0.21%	0.11%	0.01%	0.05%
4	0.07%	0.08%	0.02%	0.20%	0.06%	0.05%	0.06%	0.06%	0.12%	0.06%	0.06%	0.07%
5	0.02%	0.21%*	-0.01%	0.06%	-0.07%	0.06%	-0.07%	0.05%	-0.22%	0.05%	0.04%	0.02%
6	-0.14%	-0.35%***	-0.07%	-0.19%	-0.02%	-0.12%	-0.02%	-0.17%	-0.03%	-0.09%	-0.12%	-0.14%
7	-0.08%	-0.09%	-0.06%	-0.08%	0.10%*	-0.05%	0.10%*	-0.10%	-0.34%**	0.15%	-0.08%	-0.08%
8	-0.10%	-0.08%	-0.17%*	0.05%	-0.21%***	-0.02%	-0.21%***	-0.06%	-0.20%	-0.08%	-0.06%	-0.10%
9	-0.20%**	-0.16%	-0.23%**	-0.09%**	-0.16%**	-0.27%**	-0.16%**	-0.32%**	-0.22%	-0.18%*	-0.19%*	-0.20%**
10	-0.19%**	-0.11%	-0.35%****	0.05%**	-0.07%	-0.23%**	-0.07%	-0.16%	0.02%	-0.36%****	-0.01%	-0.20%**
11	-0.02%	0.06%	-0.05%	-0.01%	0.05%	-0.09%	0.05%	-0.06%	-0.18%	-0.04%	-0.03%	-0.03%
12	0.20%**	0.23%**	0.15%	0.23%**	-0.08%	0.31%***	-0.08%	0.23%*	-0.02%	0.31%***	0.26%**	0.20%**
13	-0.01%	-0.17%	0.08%	-0.19%	0.04%	-0.01%	0.04%	-0.08%	0.19%	0.00%	-0.19%*	0.00%
14	0.06%	0.09%	-0.01%	0.09%	-0.06%	0.01%	-0.06%	-0.19%	0.28%*	0.03%	0.07%	0.06%
15	0.03%	-0.17%	0.09%	-0.10%	0.09%	-0.13%	0.09%	-0.02%	-0.01%	0.15%	-0.08%	0.04%
16	0.05%	0.08%	0.06%	0.02%	-0.03%	0.15%	-0.03%	0.01%	0.22%	0.03%	0.17%*	0.05%
17	0.13%	0.06%	0.07%	0.18%	-0.03%	0.07%	-0.03%	0.10%	0.09%	0.23%**	0.00%	0.13%
18	0.01%	0.00%	-0.01%	0.03%	0.05%	0.03%	0.05%	0.10%	0.29%*	-0.02%	-0.12%	0.02%
19	0.09%	0.21%*	0.02%	0.18%	0.05%	0.13%	0.05%	-0.09%	0.20%	0.14%	0.23%**	0.07%
20	-0.02%	-0.19%*	-0.06%	-0.04%	-0.13%**	0.10%	-0.13%**	-0.03%	-0.05%	0.07%	-0.02%	-0.03%

Panel B reports the mean estimated coefficients from the local AFFM model in Equation (6.1). The coefficients are estimated in the estimation window prior to all announcements of the 2nd position, and the mean coefficient is reported below. As the values below are averages across all events tested, no significance tests are provided. Qualitatively, the mean coefficients below are similar to those reported for the local AFFM in Chapter 5 (Table 5.5). Similar estimates of systematic risk gives greater confidence to the isolation of the unsystematic component in Panel A. Further, the similarity between the coefficients in Panel B and those in Table 5.5 show that nonsynchronous and thin trading have not biased estimated parameters.

PANEL B: Mean Estimated Coefficients from the Local AFFM

	Energy Utilities	High-BE/ME	Mid-BE/ME	Low-BE/ME	Upper	Medium	Down	Electric	Natural Gas	Multi-Utility	Small	Big
$\bar{b}_i$	0.5981	0.4374	0.6483	0.5188	0.2455	0.5983	0.2455	0.5436	0.7146	0.5351	0.5146	0.6035
$\bar{s}_i$	-0.2765	-0.2414	-0.2894	-0.2847	-0.1104	-0.2866	-0.1104	-0.2077	-0.2717	-0.2757	0.4198	-0.3226
$\bar{h}_i$	-0.1015	0.6453	-0.0916	-0.2620	-0.0315	-0.0907	-0.0315	-0.0755	-0.1671	-0.1095	0.0852	-0.1130
$\bar{m}_i$	-0.0336	0.0154	-0.0173	-0.0670	0.4623	0.0281	-0.5377	-0.0603	0.0563	-0.0302	-0.0421	-0.0328
$\overline{tp}_i$	-0.0670	0.1011	-0.2555	0.1645	-0.0476	-0.3043	-0.0476	0.0134	-0.3200	-0.1861	-0.4275	-0.0373
$\bar{o}_i$	0.0089	0.0106	0.0070	0.0089	0.0119	0.0074	0.0119	0.0180	0.0229	-0.0078	0.0050	0.0091
$\bar{c}_i$	-0.0331	0.0306	-0.0508	0.0009	-0.0124	-0.0322	-0.0124	-0.0213	-0.0571	-0.0149	0.0001	-0.0347
$\bar{g}_i$	0.0004	-0.0025	0.0033	-0.0032	0.0045	-0.0012	0.0045	0.0024	0.0126	-0.0024	0.0002	0.0003
$\bar{\alpha}_i$	0.0008	0.0006	0.0012	0.0004	0.0008	0.0010	0.0008	0.0009	0.0006	0.0014	0.0014	0.0008
$\overline{\boldsymbol{Adj.R^2}}$	0.7243	0.6962	0.6667	0.6510	0.6076	0.6185	0.7194	0.5872	0.5455	0.6151	0.5264	0.7311

TABLE G.3: ARS SURROUNDING THE SIGNATURE DATE

Panel A presents the Abnormal Returns (ARs) for the 12 energy portfolios over the (-20,20) event window. Event days are relative to the announcement of the 1st position. For each portfolio, the t-statistics is calculated as the AR at day t divided by the standard deviation of ARs over the estimation window (day -21 to -121). The t-test examines whether the observed ARs is significant different from zero. A ****, ***, ** or * denotes significance at 0.1%, 1%, 5% or 10%, respectively.

PANEL A: Abnormal Returns

	Portfolios											
Day	**Energy Utilities**	**High-BE/ME**	**Mid-BE/ME**	**Low-BE/ME**	**Upper**	**Medium**	**Down**	**Electric**	**Natural Gas**	**Multi-Utility**	**Small**	**Big**
-20	0.03%	-0.01%	-0.03%	0.07%	0.03%	0.00%	0.03%	0.03%	0.00%	0.00%	0.02%	0.03%
-19	0.12%*	0.01%	0.11%	0.06%*	0.12%**	0.02%	0.12%**	0.09%	-0.07%	0.17%*	0.08%	0.12%*
-18	-0.03%	0.07%	-0.07%	0.01%	0.00%	-0.09%	0.00%	0.03%	0.08%	-0.15%	-0.01%	-0.03%
-17	-0.07%	-0.24%**	-0.04%	-0.07%	0.01%	-0.07%	0.01%	0.00%	-0.19%	-0.11%	-0.07%	-0.07%
-16	-0.04%	0.01%	-0.06%	-0.02%	-0.04%	-0.06%	-0.04%	0.07%	-0.16%	-0.02%	-0.06%	-0.04%
-15	-0.07%	-0.01%	-0.16%*	0.01%	-0.08%	-0.07%	-0.08%	-0.02%	-0.15%	-0.18%*	-0.06%	-0.07%
-14	-0.13%*	0.13%	-0.17%*	-0.07%*	0.02%	-0.24%***	0.02%	-0.12%	0.02%	-0.13%	-0.03%	-0.13%*
-13	-0.12%*	-0.17%	-0.12%	-0.07%*	-0.13%**	-0.10%	-0.13%**	-0.06%	-0.29%*	-0.07%	-0.07%	-0.13%*
-12	-0.10%	-0.09%	-0.16%*	0.02%	-0.07%	-0.17%*	-0.07%	-0.14%*	-0.20%	-0.07%	-0.14%	-0.10%
-11	-0.10%	0.02%	-0.15%*	-0.04%	-0.09%	-0.09%	-0.09%	-0.13%	-0.01%	-0.03%	-0.08%	-0.09%
-10	-0.03%	-0.08%	-0.02%	-0.04%	-0.03%	-0.01%	-0.03%	0.02%	-0.11%	-0.03%	0.06%	-0.04%
-9	-0.14%**	0.17%	-0.30%***	0.05%**	-0.14%**	-0.15%*	-0.14%**	-0.13%	-0.01%	-0.26%***	-0.03%	-0.15%**
-8	0.11%	0.12%	0.12%	0.00%	-0.03%	0.12%	-0.03%	0.11%	0.22%	-0.06%	0.09%	0.10%
-7	0.03%	-0.01%	0.00%	0.08%	-0.23%****	0.09%	-0.23%****	0.05%	-0.07%	0.10%	-0.01%	0.03%
-6	-0.13%*	-0.12%	-0.15%*	-0.11%*	-0.05%	-0.14%	-0.05%	-0.07%	-0.13%	-0.16%*	-0.07%	-0.13%*
-5	0.00%	0.01%	0.00%	-0.02%	-0.10%*	0.01%	-0.10%*	-0.11%	-0.01%	-0.03%	0.09%	-0.01%
-4	-0.08%	-0.04%	-0.18%*	0.15%	-0.06%	-0.01%	-0.06%	-0.07%	-0.27%*	-0.05%	0.00%	-0.09%
-3	0.03%	0.08%	0.07%	-0.03%	0.02%	0.03%	0.02%	0.11%	0.06%	0.10%	0.00%	0.03%
-2	-0.01%	0.10%	-0.11%	0.10%	-0.01%	-0.12%	-0.01%	0.03%	-0.33%**	-0.02%	0.03%	-0.02%
-1	0.01%	-0.06%	-0.03%	0.07%	-0.04%	0.12%	-0.04%	-0.07%	0.14%	0.00%	0.00%	0.01%
0	0.05%	0.11%	0.08%	-0.06%	0.02%	0.17%**	0.02%	-0.06%	0.23%	0.12%	0.01%	0.05%
1	0.03%	-0.02%	-0.01%	0.05%	0.03%	0.06%	0.03%	-0.15%*	0.24%	0.07%	0.10%	0.02%
2	0.01%	0.06%	-0.09%	0.10%	-0.01%	0.05%	-0.01%	-0.05%	-0.10%	0.08%	0.06%	0.01%
3	-0.03%	-0.02%	0.00%	0.01%	-0.05%	0.09%	-0.05%	-0.02%	-0.19%	0.05%	0.03%	-0.03%
4	0.10%	0.04%	0.12%	0.07%	-0.08%	0.20%**	-0.08%	0.16%*	-0.12%	0.12%	0.12%	0.10%
5	-0.04%	-0.04%	0.01%	-0.07%	-0.17%***	0.04%	-0.17%***	0.04%	0.00%	-0.03%	0.00%	-0.04%
6	-0.13%*	-0.03%	-0.22%**	-0.08%*	-0.06%	-0.18%**	-0.06%	-0.12%	-0.17%	-0.25%**	-0.03%	-0.14%*
7	0.00%	0.05%	-0.04%	0.08%	-0.02%	-0.06%	-0.02%	0.10%	-0.13%	-0.01%	0.07%	-0.01%
8	0.12%	0.21%**	0.14%	0.12%	0.08%	0.08%	0.08%	0.17%*	0.03%	0.00%	0.25%***	0.11%
9	-0.04%	-0.11%	-0.06%	0.03%	-0.11%**	-0.02%	-0.11%**	0.05%	-0.05%	-0.11%	-0.03%	-0.04%
10	-0.11%	-0.07%	-0.11%	-0.12%	-0.02%	-0.07%	-0.02%	-0.23%**	0.14%	-0.13%	0.01%	-0.11%
11	0.04%	-0.05%	0.04%	0.08%	0.04%	-0.01%	0.04%	0.05%	-0.08%	0.05%	0.04%	0.04%
12	0.01%	-0.05%	0.04%	0.00%	-0.07%	0.02%	-0.07%	0.15%*	-0.09%	-0.05%	0.07%	0.01%
13	0.06%	-0.09%	0.12%	0.00%	-0.09%*	0.10%	-0.09%*	0.04%	0.08%	0.01%	0.11%	0.06%
14	0.06%	0.22%**	0.02%	0.07%	0.03%	0.07%	0.03%	0.00%	-0.15%	0.14%	0.05%	0.06%
15	0.04%	0.04%	0.00%	0.08%	0.02%	0.02%	0.02%	0.04%	-0.29%*	0.06%	0.09%	0.03%
16	-0.07%	-0.09%	-0.13%	0.03%	0.10%*	-0.20%**	0.10%*	-0.11%	-0.14%	0.02%	0.06%	-0.08%
17	0.07%	0.07%	0.04%	0.01%	-0.02%	0.03%	-0.02%	0.19%**	0.00%	0.11%	-0.01%	0.07%
18	0.01%	0.12%	0.01%	-0.05%	-0.02%	-0.03%	-0.02%	-0.03%	-0.03%	0.01%	0.05%	0.01%
19	0.08%	0.39%****	0.05%	0.17%	0.01%	0.16%*	0.01%	0.11%	0.10%	0.17%*	0.26%***	0.07%
20	0.02%	-0.05%	-0.03%	0.09%	0.07%	-0.04%	0.07%	0.08%	0.04%	-0.05%	-0.06%	0.03%

Panel B reports the mean estimated coefficients from the local AFFM model in Equation (6.1). The coefficients are estimated in the estimation window prior to all announcements of the signature date, and the mean coefficient is reported below. As the values below are averages across all events tested, no significance tests are provided. Qualitatively, the mean coefficients below are similar to those reported for the local AFFM in Chapter 5 (Table 5.5). Similar estimates of systematic risk gives greater confidence to the isolation of the unsystematic component in Panel A. Further, the similarity between the coefficients in Panel B and those in Table 5.5 show that nonsynchronous and thin trading have not biased estimated parameters.

PANEL B: Mean Estimated Coefficients from the Local AFFM

	Energy Utilities	**High-BE/ME**	**Mid-BE/ME**	**Low-BE/ME**	**Upper**	**Medium**	**Down**	**Electric**	**Natural Gas**	**Multi-Utility**	**Small**	**Big**
$\bar{b}_i$	0.6054	0.4325	0.6673	0.5060	0.2549	0.5955	0.2549	0.5498	0.7429	0.5385	0.5012	0.6123
$\bar{s}_i$	-0.2913	-0.2612	-0.2969	-0.3005	-0.1238	-0.3058	-0.1238	-0.2221	-0.3063	-0.3016	0.4474	-0.3403
$\bar{h}_i$	-0.0858	0.6665	-0.0774	-0.2686	-0.0340	-0.0757	-0.0340	-0.0559	-0.1490	-0.1095	0.1072	-0.0977
$\bar{m}_i$	-0.0419	0.0040	-0.0265	-0.0813	0.4516	0.0164	-0.5484	-0.0655	0.0130	-0.0311	-0.0473	-0.0413
$\overline{tp}_i$	0.1056	0.0045	0.0055	0.3129	-0.0081	0.0214	-0.0081	0.2244	-0.0501	0.0563	-0.0900	0.1226
$\bar{o}_i$	0.0100	0.0123	0.0106	0.0033	0.0096	0.0135	0.0096	0.0217	0.0257	-0.0086	0.0077	0.0100
$\bar{c}_i$	-0.0311	0.0196	-0.0464	-0.0057	-0.0119	-0.0285	-0.0119	-0.0397	-0.0436	-0.0068	-0.0026	-0.0324
$\bar{g}_i$	0.0006	0.0010	0.0025	-0.0010	0.0029	0.0026	0.0029	0.0035	0.0134	-0.0021	0.0028	0.0003
$\bar{\alpha}_i$	0.0004	0.0003	0.0007	-0.0001	0.0005	0.0005	0.0005	0.0003	0.0000	0.0009	0.0005	0.0004
$\overline{\boldsymbol{Adj.}}$	0.7540	0.7005	0.6915	0.6636	0.6189	0.6392	0.7419	0.6051	0.5503	0.6311	0.5320	0.7619

TABLE G.4: ARS SURROUNDING THE PUBLICATION DATE

Panel A presents the Abnormal Returns (ARs) for the 12 energy portfolios over the (-20,20) event window. Event days are relative to the announcement of the 1st position. For each portfolio, the t-statistics is calculated as the AR at day t divided by the standard deviation of ARs over the estimation window (day -21 to -121). The t-test examines whether the observed ARs is significant different from zero. A ****, ***, ** or * denotes significance at 0.1%, 1%, 5% or 10%, respectively.

PANEL A: Abnormal Returns

	Portfolios											
Day	**Energy Utilities**	**High-BE/ME**	**Mid-BE/ME**	**Low-BE/ME**	**Upper**	**Medium**	**Down**	**Electric**	**Natural Gas**	**Multi-Utility**	**Small**	**Big**
-20	-0.16%**	-0.51%****	-0.12%	-0.19%**	0.04%	-0.21%**	0.04%	-0.17%	-0.15%	-0.03%	-0.15%	-0.16%**
-19	0.09%	0.11%	0.11%	0.08%	-0.11%**	0.11%	-0.11%**	0.11%	-0.07%	0.20%*	0.12%	0.10%
-18	0.08%	0.10%	0.05%	0.14%	0.02%	0.15%	0.02%	0.03%	0.07%	0.12%	0.10%	0.08%
-17	0.00%	0.13%	-0.10%	0.08%	-0.19%***	0.03%	-0.19%***	-0.01%	0.06%	-0.05%	0.03%	-0.01%
-16	0.03%	0.20%*	-0.02%	0.10%	0.04%	-0.07%	0.04%	0.10%	-0.24%	-0.07%	0.09%	0.03%
-15	0.15%*	0.06%	0.19%*	-0.02%*	0.08%	0.11%	0.08%	0.17%*	0.28%*	0.00%	0.10%	0.16%*
-14	0.08%	0.30%***	0.06%	0.10%	-0.01%	0.03%	-0.01%	0.12%	-0.12%	0.10%	0.14%	0.07%
-13	0.04%	0.14%	-0.02%	0.13%	0.02%	0.10%	0.02%	0.06%	-0.02%	-0.02%	0.11%	0.03%
-12	-0.03%	-0.10%	-0.01%	-0.03%	0.02%	0.08%	0.02%	-0.02%	-0.13%	-0.03%	0.00%	-0.03%
-11	0.00%	-0.02%	0.00%	0.02%	-0.06%	0.03%	-0.06%	-0.02%	0.13%	0.04%	0.00%	0.00%
-10	-0.06%	0.03%	-0.16%	-0.03%	-0.01%	0.09%	-0.01%	0.02%	-0.07%	-0.07%	0.04%	-0.07%
-9	-0.09%	-0.10%	-0.09%	-0.06%	-0.07%	-0.12%	-0.07%	-0.09%	-0.22%	-0.05%	-0.02%	-0.10%
-8	-0.04%	-0.09%	-0.05%	-0.05%	-0.02%	-0.02%	-0.02%	-0.11%	-0.15%	0.06%	-0.01%	-0.04%
-7	-0.10%	0.04%	-0.12%	0.03%	-0.07%	-0.15%	-0.07%	0.01%	0.05%	-0.19%*	-0.03%	-0.10%
-6	0.03%	-0.05%	0.03%	-0.03%	0.09%	-0.03%	0.09%	-0.08%	-0.08%	0.08%	-0.02%	0.04%
-5	-0.03%	-0.01%	-0.01%	0.03%	-0.11%*	0.07%	-0.11%*	0.05%	-0.14%	-0.02%	0.10%	-0.04%
-4	0.05%	0.18%*	0.06%	0.00%	0.02%	0.06%	0.02%	0.08%	0.08%	0.03%	0.11%	0.05%
-3	0.17%**	0.15%	0.19%*	0.09%**	0.15%**	0.10%	0.15%**	0.14%	0.31%**	0.17%*	0.10%	0.17%**
-2	0.13%	0.15%	0.19%*	0.06%	0.07%	0.01%	0.07%	0.14%	0.00%	0.14%	0.11%	0.13%
-1	-0.09%	-0.19%*	-0.05%	-0.20%	0.00%	-0.20%**	0.00%	-0.32%***	-0.17%	0.11%	0.00%	-0.10%
0	-0.02%	-0.05%	0.01%	-0.05%	-0.05%	0.01%	-0.05%	-0.02%	-0.03%	0.02%	0.02%	-0.02%
1	-0.02%	0.06%	-0.07%	0.04%	-0.04%	0.00%	-0.04%	-0.05%	0.15%	-0.12%	-0.01%	-0.02%
2	0.09%	0.11%	0.07%	0.17%	0.07%	0.12%	0.07%	0.14%	-0.04%	0.07%	0.20%*	0.08%
3	0.03%	-0.08%	0.06%	-0.06%	-0.01%	0.04%	-0.01%	0.04%	0.25%*	-0.06%	0.00%	0.03%
4	0.02%	0.20%*	0.01%	-0.02%	0.06%	-0.04%	0.06%	0.00%	-0.06%	0.07%	0.10%	0.01%
5	0.07%	0.08%	0.08%	0.01%	0.02%	0.00%	0.02%	0.13%	0.10%	0.08%	-0.04%	0.08%
6	-0.15%*	-0.10%	-0.16%	-0.10%*	0.06%	-0.25%**	0.06%	-0.17%	-0.33%**	-0.06%	-0.11%	-0.15%*
7	-0.06%	0.02%	-0.09%	-0.06%	-0.03%	-0.10%	-0.03%	0.02%	-0.25%*	0.01%	0.00%	-0.07%
8	-0.09%	-0.10%	-0.14%	0.00%	0.00%	-0.05%	0.00%	0.01%	0.03%	-0.26%**	-0.05%	-0.09%
9	0.12%	-0.05%	0.21%**	0.02%	-0.02%	0.14%	-0.02%	0.14%	0.22%	0.04%	0.13%	0.12%
10	0.06%	0.15%	0.06%	0.05%	-0.10%*	0.09%	-0.10%*	0.08%	-0.08%	0.10%	-0.05%	0.07%
11	0.01%	-0.10%	0.10%	-0.10%	-0.02%	-0.04%	-0.02%	-0.03%	0.21%	0.03%	-0.03%	0.01%
12	-0.11%	0.16%	-0.20%*	-0.02%	0.03%	-0.14%	0.03%	0.14%	-0.24%	-0.18%*	0.05%	-0.12%
13	0.01%	0.02%	0.09%	-0.06%	-0.03%	-0.02%	-0.03%	-0.03%	-0.02%	0.10%	-0.09%	0.02%
14	-0.06%	0.10%	-0.08%	-0.01%	-0.13%**	0.06%	-0.13%**	0.03%	-0.09%	-0.03%	-0.05%	-0.06%
15	-0.01%	0.04%	-0.02%	0.03%	-0.01%	-0.09%	-0.01%	0.02%	-0.07%	-0.01%	0.03%	-0.01%
16	-0.02%	-0.07%	-0.05%	-0.01%	0.05%	-0.05%	0.05%	-0.05%	0.01%	-0.06%	-0.10%	-0.02%
17	0.00%	0.23%**	-0.13%	0.13%	-0.09%	-0.08%	-0.09%	0.04%	0.03%	-0.03%	0.06%	0.00%
18	-0.02%	-0.13%	0.01%	-0.01%	-0.05%	0.02%	-0.05%	-0.07%	0.09%	-0.09%	-0.12%	-0.02%
19	0.06%	-0.06%	0.16%	-0.09%	-0.06%	0.15%	-0.06%	0.00%	0.22%	-0.01%	0.06%	0.05%
20	-0.04%	0.03%	-0.01%	-0.13%	-0.06%	-0.04%	-0.06%	0.17%*	-0.28%*	0.04%	-0.07%	-0.04%

Panel B reports the mean estimated coefficients from the local AFFM model in Equation (6.1). The coefficients are estimated in the estimation window prior to all announcements of the publication date, and the mean coefficient is reported below. As the values below are averages across all events tested, no significance tests are provided. Qualitatively, the mean coefficients below are similar to those reported for the local AFFM in Chapter 5 (Table 5.5). Similar estimates of systematic risk gives greater confidence to the isolation of the unsystematic component in Panel A. Further, the similarity between the coefficients in Panel B and those in Table 5.5 show that nonsynchronous and thin trading have not biased estimated parameters.

PANEL B: Mean Estimated Coefficients from the Local AFFM

	Energy Utilities	**High-BE/ME**	**Mid-BE/ME**	**Low-BE/ME**	**Upper**	**Medium**	**Down**	**Electric**	**Natural Gas**	**Multi-Utility**	**Small**	**Big**
$\bar{b}_i$	0.6121	0.4327	0.6851	0.4990	0.2601	0.6083	0.2601	0.5561	0.7299	0.5617	0.4989	0.6197
$\bar{s}_i$	-0.2876	-0.2737	-0.2850	-0.3088	-0.1214	-0.2983	-0.1214	-0.2183	-0.2958	-0.3051	0.4454	-0.3358
$\bar{h}_i$	-0.0958	0.6720	-0.0924	-0.2765	-0.0387	-0.0817	-0.0387	-0.0667	-0.1434	-0.1287	0.1029	-0.1081
$\bar{m}_i$	-0.0498	0.0040	-0.0355	-0.0838	0.4378	0.0073	-0.5622	-0.0613	-0.0115	-0.0349	-0.0520	-0.0495
$\overline{tp}_i$	0.5260	0.7720	0.3011	0.7845	-0.0586	0.5883	-0.0587	0.6226	0.3504	0.3980	0.6327	0.5198
$\bar{o}_i$	0.0112	0.0134	0.0118	0.0050	0.0115	0.0102	0.0115	0.0190	0.0253	-0.0032	0.0138	0.0108
$\bar{c}_i$	-0.0382	0.0073	-0.0529	-0.0162	-0.0153	-0.0325	-0.0153	-0.0453	-0.0456	-0.0169	-0.0156	-0.0391
$\bar{g}_i$	-0.0003	-0.0021	0.0015	-0.0024	0.0013	0.0008	0.0013	0.0044	0.0094	-0.0052	0.0014	-0.0005
$\bar{\alpha}_i$	-0.0004	-0.0007	-0.0001	-0.0009	0.0005	-0.0006	0.0005	-0.0005	-0.0001	-0.0001	-0.0007	-0.0004
$\overline{Adj.R^2}$	0.7621	0.7068	0.7013	0.6582	0.6083	0.6526	0.7545	0.6143	0.5470	0.6474	0.5473	0.7701

Appendix H. EVENT STUDIES BY REGULATORY STREAM

TABLE H.1: CAARS SURROUNDING INTERNAL ENERGY MARKET EVENTS

Specific to the Internal Energy Market, this table reports the CAARs of various event windows surrounding the 1st position, 2nd position, signature date and publication dates. The results are presented in Panels A, B, C and D, respectively. The CAARs are estimated using the local AAFM outlined in Equation (6.1). A ****, ***, ** or * denotes significance at 0.1%, 1%, 5% or 10%, respectively.

Panel A: CAARs Surrounding the 1st Position Event Windows and Significance Tests

	(-20,20)	(-20,-1)	(-10,-1)	(0,0)	(-1,1)	(-2,2)	(1,10)	(1,20)
Energy Utilities	-1.85%	-1.32% *	-1.04% **	-0.32% **	-0.62% **	-0.53%	-0.47%	-0.21%
High-BE/ME	0.75%	0.72%	-0.15%	-0.31%	-0.28%	-0.17%	-0.28%	0.34%
Mid-BE/ME	-3.49% *	-2.01% *	-1.67% **	-0.29%	-0.83% **	-0.66%	-0.96%	-1.19%
Low-BE/ME	0.36%	-0.53%	0.06%	-0.31%	-0.29%	-0.39%	0.24%	1.20%
Upper	-1.09%	-0.49%	-1.02% **	-0.25% **	-0.55% **	-0.71% **	-0.31%	-0.36%
Medium	-2.43%	-2.26% **	-1.13% *	-0.23%	-0.60% **	-0.56%	-0.21%	0.06%
Down	-1.09%	-0.49%	-1.02% **	-0.25% **	-0.55% **	-0.71% **	-0.31%	-0.36%
Electric	-0.32%	-0.68%	-0.68%	-0.28% *	-0.53%	-0.40%	0.06%	0.64%
Natural Gas	-6.26%	-4.05%	-1.04%	-0.17%	-0.56%	-0.63%	-0.52%	-2.05%
Multi-Utility	-2.49%	-1.29%	-1.00% *	-0.40% *	-0.37%	-0.52%	-0.58%	-0.80%
Small	-1.00%	-0.58%	-0.39%	-0.32% *	-0.57% *	-0.57%	-0.29%	-0.10%
Big	-1.95%	-1.39% *	-1.10% **	-0.32% **	-0.63% *	-0.54%	-0.49%	-0.24%

Panel B: CAARs Surrounding the 2nd Position Event Windows and Significance Tests

	(-20,20)	(-20,-1)	(-10,-1)	(0,0)	(-1,1)	(-2,2)	(1,10)	(1,20)
Energy Utilities	-0.83%	-1.46%	-0.27%	0.32% **	0.28%	-0.15%	-1.12%	0.31%
High-BE/ME	-0.83%	-0.81%	-0.07%	0.38%	0.17%	-0.63%	-1.05%	-0.39%
Mid-BE/ME	-1.44%	-1.33%	-0.34%	0.29% *	0.24%	-0.09%	-1.27%	-0.40%
Low-BE/ME	0.07%	-1.49%	0.10%	0.30%	0.45%	-0.15%	-0.61%	1.26%
Upper	-1.88%	-1.28% *	-0.57%	0.20%	0.10%	0.03%	-0.71%	-0.80%
Medium	0.16%	-0.90%	-0.03%	0.29% *	0.19%	-0.03%	-0.99%	0.78%
Down	-1.88%	-1.28% *	-0.57%	0.20%	0.10%	0.03%	-0.71%	-0.80%
Electric	-1.91%	-1.29%	-0.06%	0.36% *	0.34%	-0.04%	-0.93%	-0.99%
Natural Gas	1.15%	-0.17%	0.46%	0.26%	0.57%	-0.46%	-0.43%	1.06%
Multi-Utility	-1.47%	-2.31% **	-0.89%	0.30%	0.17%	0.10%	-1.34%	0.54%
Small	-1.39%	-1.04%	0.05%	0.14%	0.26%	-0.32%	-1.05%	-0.49%
Big	-0.87%	-1.52%	-0.30%	0.33% **	0.28%	-0.14%	-1.13%	0.33%

	Panel C: CAARs Surrounding the Signature Date Event Windows and Significance Tests							
	(-20,20)	**(-20,-1)**	**(-10,-1)**	**(0,0)**	**(-1,1)**	**(-2,2)**	**(1,10)**	**(1,20)**
Energy Utilities	0.16%	-0.51%	0.08%	0.11%	0.23%	0.30%	0.31%	0.56%
High-BE/ME	-0.20%	-0.04%	0.19%	0.08%	0.26%	0.44%	0.30%	-0.24%
Mid-BE/ME	0.28%	-0.87%	-0.17%	0.17%	0.13%	0.11%	0.39%	0.97%
Low-BE/ME	0.94%	0.48%	0.66%	0.12%	0.49%	0.62%	0.40%	0.34%
Upper	-1.94%	-1.32%	-0.88%	0.15%	0.25%	0.27%	-0.83% **	-0.77%
Medium	0.74%	-0.64%	0.38%	0.21%	0.64% ***	0.87% *	0.83%	1.17%
Down	-1.94%	-1.32%	-0.88%	0.15%	0.25%	0.27%	-0.83% **	-0.77%
Electric	0.48%	-0.31%	0.01%	-0.11%	-0.33%	-0.19%	0.56%	0.89%
Natural Gas	-1.68%	-1.33%	-0.06%	0.25%	1.14%	0.06%	0.17%	-0.60%
Multi-Utility	0.87%	-0.22%	-0.04%	0.27%	0.43%	0.86%	0.61%	0.82%
Small	0.66%	-0.66%	0.17%	0.14%	0.31%	0.63%	0.82%	1.18%
Big	0.12%	-0.51%	0.07%	0.11%	0.22%	0.28%	0.29%	0.52%

	Panel D: CAARs Surrounding the Publication Date Event Windows and Significance Tests							
	(-20,20)	**(-20,-1)**	**(-10,-1)**	**(0,0)**	**(-1,1)**	**(-2,2)**	**(1,10)**	**(1,20)**
Energy Utilities	0.24%	0.58%	0.15%	0.09%	-0.19%	0.04%	0.50%	-0.43%
High-BE/ME	0.49%	1.15%	0.96%	-0.09%	-1.26% **	-0.70%	-0.46%	-0.58%
Mid-BE/ME	0.83%	0.46%	0.07%	0.17% *	0.03%	0.27%	1.06%	0.20%
Low-BE/ME	0.18%	0.79%	0.29%	-0.01%	-0.31%	0.13%	0.08%	-0.59%
Upper	-1.20%	-0.54%	0.01%	-0.04%	0.01%	0.17%	0.11%	-0.63%
Medium	1.20%	0.73%	0.06%	0.24% **	-0.22%	0.16%	0.98%	0.23%
Down	-1.20%	-0.54%	0.01%	-0.04%	0.01%	0.17%	0.11%	-0.63%
Electric	0.70%	0.25%	0.30%	0.31%	-0.45%	-0.32%	0.12%	0.15%
Natural Gas	-2.21%	-1.91%	-1.01%	-0.01%	-0.09%	0.03%	0.45%	-0.29%
Multi-Utility	0.97%	1.51%	0.55%	-0.08%	-0.12%	0.34%	0.94%	-0.46%
Small	0.54%	1.07%	0.58%	0.11%	-0.22%	0.17%	0.42%	-0.64%
Big	0.23%	0.57%	0.13%	0.09%	-0.19%	0.03%	0.51%	-0.42%

TABLE H.2: CAARS SURROUNDING ENERGY EFFICIENCY EVENTS

Specific to the Energy Efficiency stream, this table reports the CAARs of various event windows surrounding the 1st position, 2nd position, signature date and publication dates. The results are presented in Panels A, B, C and D, respectively. The CAARs are estimated using the local AAFM outlined in Equation (6.1). A ****, ***, ** or * denotes significance at 0.1%, 1%, 5% or 10%, respectively.

Panel A: CAARs Surrounding the 1st Position Event Windows and Significance Tests

	(-20,20)	(-20,-1)	(-10,-1)	(0,0)	(-1,1)	(-2,2)	(1,10)	(1,20)
Energy Utilities	-0.52%	0.18%	-0.28%	0.08%	-0.15%	-0.19%	-0.39%	-0.77%
High-BE/ME	-1.31%	0.04%	-0.57%	-0.13%	-0.16%	-0.60% **	-1.02% *	-1.22%
Mid-BE/ME	-1.26%	-0.36%	-0.18%	0.02%	-0.41%	-0.21%	-0.38%	-0.93%
Low-BE/ME	1.07%	0.99%	-0.41%	0.18%	0.29%	-0.05%	-0.18%	-0.11%
Upper	-0.10%	0.26%	-0.33%	0.11%	0.00%	-0.05%	0.00%	-0.46%
Medium	-1.73%	-0.25%	-0.14%	-0.17%	-0.40%	-0.39%	-0.73%	-1.31%
Down	-0.10%	0.26%	-0.33%	0.11%	0.00%	-0.05%	0.00%	-0.46%
Electric	0.09%	0.21%	-0.34%	0.14%	-0.11%	0.02%	0.27%	-0.26%
Natural Gas	-3.30% *	-0.63%	0.19%	0.01%	-0.11%	-0.18%	-1.17%	-2.67% *
Multi-Utility	0.01%	0.46%	-0.15%	-0.03%	-0.14%	-0.24%	-0.48%	-0.42%
Small	-1.51%	0.01%	-0.51%	-0.06%	-0.09%	-0.30%	-0.61%	-1.46% *
Big	-0.44%	0.21%	-0.25%	0.08%	-0.16%	-0.18%	-0.38%	-0.73%

Panel B: CAARs Surrounding the 2nd Position Event Windows and Significance Tests

	(-20,20)	(-20,-1)	(-10,-1)	(0,0)	(-1,1)	(-2,2)	(1,10)	(1,20)
Energy Utilities	-2.13%	-1.60% **	-1.07% **	0.01%	0.25%	-0.19%	-1.22%	-0.54%
High-BE/ME	-3.08%	-2.44% **	-1.28% **	0.13%	0.26%	-0.32%	-1.24%	-0.77%
Mid-BE/ME	-2.43%	-1.41%	-1.03% *	0.02%	0.36%	0.04%	-1.37%	-1.04%
Low-BE/ME	-2.24% *	-1.90% **	-1.20% **	-0.14%	-0.23%	-0.79% *	-0.96%	-0.20%
Upper	0.00%	-0.25%	0.13%	0.09%	0.39% *	0.39%	0.22%	0.15%
Medium	-3.39% **	-2.37% **	-1.69% ***	-0.05%	0.04%	-0.37%	-1.60%	-0.97%
Down	0.00%	-0.25%	0.13%	0.09%	0.39% *	0.39%	0.22%	0.15%
Electric	-3.66% *	-2.04% **	-1.25% **	0.04%	0.28%	-0.19%	-1.42%	-1.66%
Natural Gas	-1.07%	-1.65%	-0.42%	0.03%	0.18%	-0.37%	-1.59%	0.55%
Multi-Utility	-1.15%	-1.32%	-1.06% *	-0.02%	0.29%	-0.02%	-0.90%	0.19%
Small	-2.62% *	-2.43% **	-1.22% ***	0.08%	0.15%	-0.32%	-1.14%	-0.27%
Big	-2.10%	-1.54% *	-1.06% **	0.01%	0.26%	-0.17%	-1.23%	-0.56%

Panel C: CAARs Surrounding the Signature Date Event Windows and Significance Tests

	(-20,20)	(-20,-1)	(-10,-1)	(0,0)	(-1,1)	(-2,2)	(1,10)	(1,20)
Energy Utilities	-0.18%	-0.86%	-0.18%	0.03%	-0.03%	-0.05%	-0.12%	0.65%
High-BE/ME	0.81%	-0.35%	0.41%	0.04%	0.01%	-0.04%	0.12%	1.13%
Mid-BE/ME	-1.63%	-1.66% *	-0.77%	0.06%	-0.15%	-0.35%	-0.46%	-0.03%
Low-BE/ME	1.22%	-0.16%	0.47%	-0.13%	-0.02%	0.10%	0.46%	1.50% *
Upper	-1.14%	-0.87%	-0.69%	0.01%	-0.16%	-0.19%	-0.63% *	-0.29%
Medium	-0.38%	-1.20%	-0.24%	0.15%	0.25%	0.07%	0.16%	0.67%
Down	-1.14%	-0.87%	-0.69%	0.01%	-0.16%	-0.19%	-0.63% *	-0.29%
Electric	0.17%	-0.44%	0.06%	-0.03%	-0.32%	-0.45%	-0.11%	0.64%
Natural Gas	-1.86%	-1.63%	-0.44%	0.18%	0.23%	0.19%	-0.60%	-0.40%
Multi-Utility	-0.58%	-1.29%	-0.57%	0.03%	0.00%	-0.13%	-0.48%	0.67%
Small	1.80%	-0.38%	0.24%	-0.05%	0.01%	-0.05%	0.78% *	2.22% **
Big	-0.30%	-0.89%	-0.22%	0.04%	-0.03%	-0.05%	-0.17%	0.55%

Panel D: CAARs Surrounding the Publication Date Event Windows and Significance Tests

	(-20,20)	(-20,-1)	(-10,-1)	(0,0)	(-1,1)	(-2,2)	(1,10)	(1,20)
Energy Utilities	0.29%	-0.06%	-0.04%	-0.10%	-0.07%	0.24%	0.31%	0.45%
High-BE/ME	1.65%	0.27%	-0.12%	-0.13%	0.10%	0.31%	1.00%	1.52% *
Mid-BE/ME	-0.20%	-0.19%	0.00%	-0.11%	-0.13%	0.23%	0.04%	0.10%
Low-BE/ME	0.21%	-0.23%	-0.25%	-0.06%	-0.06%	0.09%	0.41%	0.50%
Upper	-0.22%	-0.15%	-0.02%	-0.10%	-0.15%	-0.02%	0.19%	0.03%
Medium	-0.73%	-0.41%	-0.37%	-0.08%	-0.20%	-0.09%	-0.14%	-0.24%
Down	-0.22%	-0.15%	-0.02%	-0.10%	-0.15%	-0.02%	0.19%	0.03%
Electric	1.12%	0.05%	-0.25%	-0.14%	-0.28%	0.10%	0.88%	1.20% *
Natural Gas	0.79%	-0.18%	-0.02%	-0.09%	0.05%	-0.09%	0.40%	1.07%
Multi-Utility	-0.02%	-0.01%	0.23%	0.03%	0.12%	0.36%	-0.14%	-0.05%
Small	1.33%	0.97%	0.55%	-0.02%	0.15%	0.42%	0.33%	0.38%
Big	0.23%	-0.12%	-0.08%	-0.10%	-0.08%	0.22%	0.31%	0.45%

TABLE H.3: CAARS SURROUNDING RENEWABLE ENERGIES EVENTS

Specific to the Renewable Energies stream, this table reports the CAARs of various event windows surrounding the 1st position, 2nd position, signature date and publication dates. The results are presented in Panels A, B, C and D, respectively. The CAARs are estimated using the local AAFM outlined in Equation (6.1). A ****, ***, ** or * denotes significance at 0.1%, 1%, 5% or 10%, respectively.

Panel A: CAARs Surrounding the 1st Position Event Windows and Significance Tests

	(-20,20)	(-20,-1)	(-10,-1)	(0,0)	(-1,1)	(-2,2)	(1,10)	(1,20)
Energy Utilities	-2.65%	-2.50%	-1.08%	-0.13%	-0.82%	-1.49%	-0.75%	-0.01%
High-BE/ME	-2.60%	0.57%	0.30%	-0.46%	-0.09%	-0.74%	-1.48%	-2.71%
Mid-BE/ME	-2.81%	-2.39%	-0.76%	-0.24%	-0.88%	-1.78%	-1.06%	-0.18%
Low-BE/ME	-3.76%	-5.09%	-2.33%	0.15%	-0.53%	-0.91%	0.24%	1.18%
Upper	-0.10%	-1.82%	0.07%	0.55%	0.10%	0.75%	0.45%	1.18%
Medium	-7.26%	-3.89%	-1.81%	-0.41%	-0.77%	-3.02%	-2.17%	-2.97%
Down	-0.10%	-1.82%	0.07%	0.55%	0.10%	0.75%	0.45%	1.18%
Electric	3.71%	2.07%	1.44%	-0.24%	-1.58%	-1.79%	0.37%	1.89%
Natural Gas	-8.22%	-4.91%	-3.14%	-0.03%	-1.27%	-5.36% **	-6.25% *	-3.28%
Multi-Utility	-2.99%	-3.16%	-0.47%	0.48%	0.24%	0.63%	0.68%	-0.31%
Small	-1.17%	-2.97%	-1.63%	-0.59%	-0.75%	-1.12%	1.04%	2.39%
Big	-2.69%	-2.42%	-1.02%	-0.09%	-0.81%	-1.50%	-0.87%	-0.18%

Panel B: CAARs Surrounding the 2nd Position Event Windows and Significance Tests

	(-20,20)	(-20,-1)	(-10,-1)	(0,0)	(-1,1)	(-2,2)	(1,10)	(1,20)
Energy Utilities	-3.35%	-0.59%	0.51%	0.22%	-0.30%	-1.19%	-3.48%	-2.98%
High-BE/ME	-1.64%	0.24%	0.79%	0.45%	-0.46%	-0.43%	-2.12%	-2.33%
Mid-BE/ME	-4.48%	-1.13%	0.17%	0.26%	-0.55%	-1.43%	-5.23%	-3.60%
Low-BE/ME	1.68%	1.63%	1.19%	0.19%	0.86%	-0.39%	1.31%	-0.13%
Upper	-3.20%	1.17%	1.52% ****	-0.19%	-0.89%	-2.18%	-3.88%	-4.18% *
Medium	-2.33%	-0.89%	-0.86%	0.18%	-0.30%	-1.59%	-2.16%	-1.62%
Down	-3.20%	1.17%	1.52% ****	-0.19%	-0.89%	-2.18%	-3.88%	-4.18% *
Electric	-4.71%	-2.11% **	-0.72%	0.44% *	-0.54%	-1.97%	-4.16%	-3.04%
Natural Gas	-3.26%	3.93%	1.84%	1.06%	-0.50%	-1.74%	-9.24%	-8.25%
Multi-Utility	0.51%	-1.29%	0.38%	-0.33%	-0.52%	-1.96%	-0.29%	2.13%
Small	-0.12%	1.00%	1.39%	0.07%	-0.22%	-0.52%	-0.65%	-1.20%
Big	-3.58%	-0.70%	0.44%	0.23%	-0.30%	-1.22%	-3.63%	-3.12%

	Panel C: CAARs Surrounding the Signature Date Event Windows and Significance Tests							
	(-20,20)	**(-20,-1)**	**(-10,-1)**	**(0,0)**	**(-1,1)**	**(-2,2)**	**(1,10)**	**(1,20)**
Energy Utilities	-4.23%	-4.90%	-2.77%	0.07%	0.38%	0.13%	0.34%	0.60%
High-BE/ME	-0.54%	-1.00%	-1.34%	0.68%	-1.24%	-0.26%	-1.44%	-0.22%
Mid-BE/ME	-6.88%	-7.28%	-3.67%	0.17%	1.21%	0.37%	0.57%	0.22%
Low-BE/ME	1.05%	0.22%	-1.03%	-0.32%	-1.45%	-0.76%	0.03%	1.15%
Upper	-3.17%	-3.78% *	-2.76%	0.21%	0.27%	0.12%	0.55%	0.41%
Medium	-5.31%	-5.84% *	-2.28%	0.30%	0.53%	0.14%	0.10%	0.23%
Down	-3.17%	-3.78% *	-2.76%	0.21%	0.27%	0.12%	0.55%	0.41%
Electric	-3.10%	-4.24%	-3.19% *	-0.29%	-0.69%	-0.92%	0.65%	1.43%
Natural Gas	-7.89%	-10.78%	-5.39%	1.33% **	3.55%	1.36%	2.61%	1.56% **
Multi-Utility	-2.65%	-3.09%	-0.79%	0.71%	1.07% **	1.72% **	-0.43% **	-0.27%
Small	-1.75%	-1.30%	-0.78%	-0.03%	0.15%	0.62%	0.46%	-0.42%
Big	-4.40%	-5.11%	-2.90%	0.07%	0.39%	0.07%	0.31%	0.63%

	Panel D: CAARs Surrounding the Publication Date Event Windows and Significance Tests							
	(-20,20)	**(-20,-1)**	**(-10,-1)**	**(0,0)**	**(-1,1)**	**(-2,2)**	**(1,10)**	**(1,20)**
Energy Utilities	-0.85%	0.31%	-0.14%	0.20%	-0.30%	-0.61%	-1.08%	-1.37%
High-BE/ME	1.33%	0.06%	-0.65%	0.26%	0.57%	0.42%	0.41%	1.01%
Mid-BE/ME	-1.90%	-0.06%	-0.06%	0.35%	-0.32%	-0.85%	-1.75%	-2.19%
Low-BE/ME	1.69% **	1.88%	0.08%	-0.12%	-0.64%	-0.47%	0.01%	-0.08%
Upper	-2.08%	-0.45%	-0.28%	0.09%	-0.20%	-0.27%	-1.14%	-1.72%
Medium	1.00%	0.74%	0.59%	0.11%	0.16%	0.09%	-0.22%	0.15% **
Down	-2.08%	-0.45%	-0.28%	0.09%	-0.20%	-0.27%	-1.14%	-1.72%
Electric	0.53%	0.68%	-1.31%	0.02%	-1.00%	-0.87%	-0.36%	-0.16%
Natural Gas	-5.04%	-0.70%	-0.63%	0.70% **	0.49%	0.38%	-2.77%	-5.04%
Multi-Utility	-0.98%	0.28%	0.66%	0.01%	-0.56%	-1.11%	-1.26%	-1.28% ***
Small	0.37%	0.54%	-0.15%	0.12%	-0.18%	0.12%	0.62%	-0.29%
Big	-0.87%	0.34%	-0.12%	0.21%	-0.30%	-0.65%	-1.17%	-1.41%

Table H.4: CAARs Surrounding Security of Supply Events

Specific to the Security of Supply stream, this table reports the CAARs of various event windows surrounding the 1st position, 2nd position, signature date and publication dates. The results are presented in Panels A, B, C and D, respectively. The CAARs are estimated using the local AAFM outlined in Equation (6.1). A ****, ***, ** or * denotes significance at 0.1%, 1%, 5% or 10%, respectively.

Panel A: CAARs Surrounding the 1st Position Event Windows and Significance Tests

	(-20,20)	(-20,-1)	(-10,-1)	(0,0)	(-1,1)	(-2,2)	(1,10)	(1,20)
Energy Utilities	-0.97%	-1.41%	-1.16%	-0.12%	-1.02%	-1.28% **	-0.52%	0.56%
High-BE/ME	1.91%	3.53%	1.71%	-0.46%	-0.95%	-1.74%	-1.58%	-1.16%
Mid-BE/ME	-1.08% *	-2.10%	-1.73%	0.18%	-1.20% **	-1.67% ***	-0.11%	0.83%
Low-BE/ME	-1.28%	-0.71%	-0.51%	-0.51%	-1.03%	-1.01%	-1.43% **	-0.06%
Upper	-5.66% **	-3.47%	-2.05%	-0.74% *	-1.76% *	-2.22% **	-1.22%	-1.45%
Medium	2.02% *	-1.08%	-1.12%	0.15%	-0.63%	-0.62%	0.73%	2.95%
Down	-5.66% **	-3.47%	-2.05%	-0.74% *	-1.76% *	-2.22% **	-1.22%	-1.45%
Electric	-1.99%	-1.42%	-1.40%	-0.54%	-1.52%	-2.16% *	-0.87%	-0.03%
Natural Gas	0.34%	-1.27%	-0.74%	-0.19%	0.17%	1.16%	1.62%	1.80%
Multi-Utility	1.40%	-0.39%	-0.56%	0.10%	-0.33%	-0.63%	-0.37%	1.69%
Small	-1.06%	-1.15%	-0.39%	-0.01%	-0.44%	-0.57%	-0.25%	0.10%
Big	-1.01%	-1.44%	-1.22%	-0.13%	-1.07%	-1.34% *	-0.57%	0.56%

Panel B: CAARs Surrounding the 2nd Position Event Windows and Significance Tests

	(-20,20)	(-20,-1)	(-10,-1)	(0,0)	(-1,1)	(-2,2)	(1,10)	(1,20)
Energy Utilities	-0.64%	0.44%	-0.46%	0.11%	-0.41% *	-0.42%	-0.24%	-1.20%
High-BE/ME	-1.02% **	-0.13%	-0.19%	0.18%	-0.07%	-0.24%	0.67%	-1.07%
Mid-BE/ME	1.03%	1.18%	0.16%	0.24%	-0.23%	-0.22%	-0.28%	-0.39%
Low-BE/ME	-3.11%	-0.87%	-1.82%	0.01%	-0.65% **	-1.00%	-0.32%	-2.24%
Upper	-1.47% *	-1.09%	-0.81%	-0.06%	-0.16%	-0.23%	0.12%	-0.32%
Medium	0.92%	1.81%	0.82%	0.17%	-0.24%	-0.02%	-0.52%	-1.06%
Down	-1.47% *	-1.09%	-0.81%	-0.06%	-0.16%	-0.23%	0.12%	-0.32%
Electric	-0.18%	-0.14%	-1.19%	0.18%	-0.27%	-0.40%	0.27%	-0.22%
Natural Gas	-5.18% **	-0.64%	0.43%	-0.25%	-0.58% *	-0.61%	-1.92%	-4.29%
Multi-Utility	0.45%	1.16%	-0.61%	0.14%	-0.39%	-0.43%	-0.20%	-0.86%
Small	-2.71%	-1.02%	-0.75%	0.01%	-0.09%	-0.11%	-0.05%	-1.70%
Big	-0.49%	0.54%	-0.44%	0.12%	-0.44% **	-0.43%	-0.25%	-1.16%

	Panel C: CAARs Surrounding the Signature Date Event Windows and Significance Tests							
	(-20,20)	(-20,-1)	(-10,-1)	(0,0)	(-1,1)	(-2,2)	(1,10)	(1,20)
Energy Utilities	0.42%	1.59% *	0.54%	0.02%	0.29%	0.50%	-0.26%	-1.19%
High-BE/ME	2.15%	1.83% **	0.70% *	0.36%	0.75% **	1.00%	0.70%	-0.04%
Mid-BE/ME	0.61%	1.33%	0.83%	0.03%	0.12%	0.22%	-0.29%	-0.74%
Low-BE/ME	-0.57%	1.29%	-0.04%	-0.14%	0.46%	0.88%	-0.40%	-1.73%
Upper	1.37%	0.48%	0.05%	-0.06%	0.38%	0.42%	0.73%	0.95%
Medium	1.28%	2.28% **	1.35% ***	0.10%	0.30%	0.44%	-0.11%	-1.10%
Down	1.37%	0.48%	0.05%	-0.06%	0.38%	0.42%	0.73%	0.95%
Electric	-0.41%	0.65%	-0.06%	-0.16%	-0.14%	0.11%	-0.26%	-0.90%
Natural Gas	1.69%	3.92% *	1.48%	-0.09%	0.08%	0.18%	-1.13%	-2.14%
Multi-Utility	-0.01%	0.65%	0.23%	0.19%	0.56%	0.76%	0.06%	-0.85%
Small	0.10%	0.97%	0.30%	0.03%	0.32%	0.59%	-0.06%	-0.90%
Big	0.44%	1.63% *	0.55%	0.02%	0.29%	0.49%	-0.26%	-1.21%

	Panel D: CAARs Surrounding the Publication Date Event Windows and Significance Tests							
CAARs	(-20,20)	(-20,-1)	(-10,-1)	(0,0)	(-1,1)	(-2,2)	(1,10)	(1,20)
Energy Utilities	-0.99%	0.69%	-0.38%	-0.04%	-0.26%	-0.14%	-1.60% **	-1.64% **
High-BE/ME	-1.16%	0.41%	-0.54%	0.29% **	0.41%	0.30%	-1.39%	-1.86%
Mid-BE/ME	-0.04%	0.64%	-0.07%	0.00%	-0.21%	0.03%	-1.28% *	-0.69%
Low-BE/ME	-1.80%	0.87%	-0.61%	-0.12%	-0.38%	-0.16%	-1.86% *	-2.55% **
Upper	0.89%	1.47%	0.60%	0.09%	0.10%	0.36%	-0.34%	-0.67% **
Medium	-0.45%	1.45%	-0.11%	-0.18%	-0.25%	-0.36%	-1.76% **	-1.72% *
Down	0.89%	1.47%	0.60%	0.09%	0.10%	0.36%	-0.34%	-0.67% **
Electric	0.02%	1.29%	0.15%	-0.25%	-0.25%	-0.20%	-1.20%	-1.03%
Natural Gas	-2.70%	0.21%	-0.09%	-0.17%	-0.52%	-0.25%	-1.86%	-2.74%
Multi-Utility	-1.00%	0.28%	-0.78%	0.08%	-0.16%	-0.10%	-1.75% **	-1.36%
Small	-0.71%	0.43%	-0.59%	0.00%	0.02%	0.28%	-1.36% *	-1.14%
Big	-1.01%	0.71%	-0.37%	-0.04%	-0.28%	-0.17%	-1.61% **	-1.68% **

TABLE H.5: CAARS AFTER OMITTING CONTEMPORANEOUS REGULATORY CHANGES

As noted in Table 6.1, the Internal Energy Market Stream overlaps with other restructuring streams. This table presents CAARs after omitting overlapping events. The CAARs are estimated using the local AFFM presented in Equation (6.1). A ****, ***, ** or * denotes significance at 0.1%, 1%, 5% or 10%, respectively.

			Significance Tests							
Stream	**Stage of Procedure**	**Date Deleted**	**(-20,20)**	**(-20,-1)**	**(-10,-1)**	**(0,0)**	**(-1,1)**	**(-2,2)**	**(1,10)**	**(1,20)**
Conflict #1:										
Internal Energy Market	1st Position	**22nd April 2009**	-2.14%	-1.41% *	-1.00% *A	-0.31% *A	-0.52% B	-0.40%	-0.51%	-0.42%
Security of Supply	1st Position	**22nd April 2009**	-1.98%	-1.94%	-1.02%	0.05%	-0.69%	-1.01% *A	-0.74%	-0.09%
Conflict #2:										
Internal Energy Market	2nd Position	**16th June 2003**	-0.94%	-1.71%	-0.38%	0.39% ***A	0.38%	-0.09%	-1.12%	0.38%
Internal Energy Market	Signature Date	**26th June 2003**	0.29%	-0.43%	0.20%	0.08%	0.20%	0.35%	0.37%	0.65%
Internal Energy Market	Publication Date	**15th July 2003**	0.37%	0.74%	0.13%	0.12% *B	-0.20%	0.00%	0.53%	-0.49%
Energy Efficiency	2nd Position	**16th June 2003**	-2.26%	-1.75% **	-1.18% ***A	0.04%	0.30%	-0.16%	-1.22%	-0.55%
Energy Efficiency	Signature Date	**26th June 2003**	-0.13%	-0.84%	-0.14%	0.01%	-0.05%	-0.04%	-0.11%	0.69%
Energy Efficiency	Publication Date	**15th July 2003**	0.35%	-0.01%	-0.05%	-0.09%	-0.07%	0.23%	0.32%	0.45%

A Change in magnitude or significance, but consistent direction relative to previous results
B Change from significance to insignificance (or vice versa), inconsistent with previous result.