Environment, Energy, and Economic Performance

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Kurzzusammenfassung

Die vorliegende Dissertation analysiert das Verhältnis zwischen einerseits ökonomischem Erfolg, und andererseits Umweltregulierung und Energiemarktentwicklungen. Vor dem Hintergrund, dass negative ökonomische Effekte ein weitverbreiteter Einwand gegenüber ambitionierter Umweltpolitik sind, sucht diese Dissertation vor allem nach empirischer Evidenz. Dabei wird aufgezeigt, dass die ökonomischen Folgen der jüngsten Klimapolitik der Europäischen Union im besten Falle gering waren. Konsistent mit der ökonomischen Theorie wird als Hauptgrund dafür die geringe Stringenz der Regulierung identifiziert. Die Ausgestaltung von Umweltpolitik wird wiederum in den Zusammenhang polit-ökonomischer Mechanismen gestellt. Zudem zeigt diese Dissertation die wichtige Rolle von Investitionen in umweltfreundliche Technologien und Produkte auf, die eine Stimulation von Investitionen durch Umweltpolitik nahelegt. Weiterhin eröffnet die vorliegende Arbeit neue Einblicke in die ökonomischen Konsequenzen von Energiemarktentwicklungen. Sie enthält eine erste Analyse der Aktienmarkteffekte des Europäischen Emissionshandelssystems. Darin wird aufgezeigt, dass der Firmenwert aktiengehandelter europäischer Stromerzeuger vom Preis der Verschmutzungsrechte abhängig ist. Schließlich unterstreicht diese Arbeit die Relevanz der Energiemärkte für die gesamte Volkswirtschaft. Der Ölmarkt wird dabei als der – aus Sicht der Finanzmärkte – wichtigste Energiemarkt identifiziert. Dabei wird aufgezeigt, dass nicht nur Ölpreis-, sondern auch Ölvolatilitätsschwankungen auf den Aktienmarkt und damit den Wert von Aktiengesellschaften wirken. In diesem Zusammenhang belegt die Arbeit die Relevanz von Ölpreisschocks für die Arbeitslosigkeit in Deutschland. Insbesondere illustriert sie, dass der Ölpreis trotz Energieeffizienzsteigerungen auch in jüngster Zeit auf die deutsche Volkswirtschaft wirkt. Dies suggeriert einen signifikanten Anstieg der Arbeitslosigkeit in Deutschland im Falle einer erneuten Ölkrise.

Abstract

This thesis analyzes the relationship between environmental regulation as well as energy market developments on the one hand, and economic performance on the other. Due to its economic effects environmental regulation is controversially disputed. The thesis shows, however, that the economic impacts of the recently adopted climate policy in Europe, namely of the implementation of the European Union Emission Trading Scheme, have been modest at most. Consistent with economic theory, the low stringency of this regulatory measure that is aimed at combating man-made climate change is identified as one important driver of this result. Moreover, results presented in this thesis also indicate the important role which the political economy plays for the design of environmental regulation in general. These mechanisms are shown to be a driver of the low stringency and, consequently, of the small economic effects during the first phase of the European Union Emission Trading Scheme. The thesis highlights the role of investment stimulation if the goal of environmental regulation is not only the protection of the environment, but also the compatibility with economic goals. This thesis also provides new insights into the role of energy market developments for the economy. In this respect, the relevance of the EU carbon market for the financial market performance of European electricity generators is shown. Besides, this thesis particularly demonstrates the paramount importance of oil market developments for the economy as a whole. It suggests that amongst all natural resources, oil is the most relevant one to the pricing of Eurozone energy stocks. It is also shown that besides oil prices, oil volatility plays an important role for stock market development. Finally, the thesis highlights the relevance of oil market developments to the overall economy, in showing that unemployment in Germany is strongly affected by oil price shocks. In this respect, it also opposes claims that the German oil to macroeconomy relationship has weakened since the 1980s. This suggests that an emerging oil crisis would imply a significant increase in German unemployment.

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Nomenclature

ADF	Augmented Dickey Fuller
AIC	Akaike Information Critertion
AMADEUS	Analyse Major Databases from European Sources
APX	Amsterdam Power Exchange
AR(MA)	Autoregressive (Moving Average)
BIC	Bayesian Schwarz Information Criterion
CAPM	Capital Asset Pricing Model
CDM	Clean Development Mechanism
CITL	Community Independent Transaction Log
CO_2	Carbon Dioxide
EEX	European Energy Exchange
EIA	Energy Information Administration
ETS	Emission Trading Scheme
EUA	European Union Emission Allowance
(EU) ETS	(European Union) Emission Trading Scheme
(G)ARCH	(Generalized) Autoregressive Conditional Heteroskedasticity
GHG	Greenhouse Gas
GMM DIF	First Differenced Generalized Method of Moments Dynamic Panel Data Estimator
GVA	Gross Value Added
HHI	Herfindahl-Hirschmann Index
ICE	Intercontinental Exchange
IEA	International Energy Agency
ICT	Information and Communication Technologies
IOT	Input-Output Table
IPCC	Intergovernmental Panel on Climate Change
IRF	Impulse Response Function

IRLS	Iteratively Reweighted Least Squares
JI	Joint Implementation
KPSS	Kwiatkowski-Phillips-Schmidt-Shin
LM	Lagrange Multiplier
LSDV	Least Squares Dummy Variable
LSDVC	Nickell Bias Corrected LSDV
NACE	Nomenclature Statistique des Activités Economiques dans la Communauté Européenne (Statistical Classification of Economic Activities in the European Community)
NAP	National Allocation Plan
NOPI	Net Oil Price Increase
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary Least Squares
OPEC	Organization of the Petroleum Exporting Countries
PACE	Pollution and Abatement Costs and Expenditures
PP	Phillips-Perron
RESET	Ramsey Regression Equation Specification Error
R&D	Research and Development
SARA	Superfund Amendments and Reauthorization Act
TFP	Total Factor Productivity
UNFCC	United Nations Framework Convention on Climate Change
VAR	Vector Autoregression
ZEW	Zentrum für Europäische Wirtschafts-forschung
2SLS	Two Stage Least Squares

1. Introduction

Environment- and energy-related topics rank very high on the current – political, scientific and public – agenda. As “continued green house gas emissions at or above current rates would cause further warming and induce many changes in the global climate system” (IPCC, 2007) many researchers argue in favour of strong and early action for greenhouse gas (GHG) mitigation. From an economic point of view, such commitment is generally justified by the existence of a market failure. In the case of GHG emissions, negative externalities in the form of transboundary pollution indicate the need for political intervention in order to correct market prices by taking into account external costs. In this respect, at least the so-called Stern Review (Stern, 2007) claims that strong and early action for GHG mitigation may even “considerably outweigh the costs” of global warming that would incur under a business-as-usual, i.e., no policy scenario. The exact quantification of externalities of GHG emissions is, however, a topic of current economic research.

Against this background, a major field of research in environmental and resource economics during the last years has been the economics of climate change. Mainly based on theoretical and numerical modeling exercises, the central aim of the work in this sub-discipline has been the identification of targeted international climate policy regimes as well as the projection of their associated welfare costs and competitiveness effects. From a political point of view, the Kyoto Protocol signed in 1997 (UNFCCC, 1997) constitutes a first major step towards combating man-made climate change in committing industrialized countries to fixed reductions in greenhouse gas emissions for the period between 2008 and 2012, although the implied commitments are of rather symbolic nature (Böhringer and Vogt, 2004). Opting for an economically efficient regulatory instrument at least for energy-intensive sectors (Böhringer et al., 2005) in order to achieve corresponding GHG reductions, the EU has implemented the European Union Emission Trading Scheme (EU ETS). This has been welcomed by many economists, since within such a cap-and-trade system reductions in GHG emissions can be achieved at least costs (e.g., Kruger and Pizer, 2004). Furthermore, with the public opinion and in particular consumers becoming more and more aware of the environmental consequences of economic activities, many firms have started to show environmental commitment going even beyond legal requirements.

By the implementation of the EU ETS, a new segment of international energy markets has been created. Since 2004, EU Emission Allowances (EUAs) are traded at several European energy exchanges. The introduction of tradable EUAs, however, has coincided with major price increases for natural resources, and particularly for oil. This development has attracted much attention, especially since after the first mayor oil crises in 1973 many observers associate energy price shocks with the threat of economic recession (Hamilton, 1983).

Reasons for the recent energy price boom are heavily debated. On the one hand, many observers claim that recent record prices for oil have been merely the consequence of speculative trading in the energy markets. This could imply that the recent development constitutes only a temporary phenomenon, thus having modest economic impact. On the other hand, it is argued that recent energy price increases have rather been a result of economic expansion. The recent surge of world oil demand triggered by Asia's economic catch-up highlights this point (Lin, 2008). If economic growth from newly industrializing Asian countries has indeed been responsible for the recent energy market developments, this could indicate that the high price levels are of permanent nature, as these economies are seen as the frontrunners in future global economic growth (e.g., Eichengreen and Tong, 2006). This demonstrates that besides action against climate change, energy market developments will also be a major concern to the world economy for years and decades to come.

The aim of this thesis is to analyze the relationship between environmental regulation as well as energy market developments on the one hand, and economic performance on the other. Due to its economic effects environmental regulation is – particularly in periods of low economic growth – widely and controversially disputed (see, e.g., the discussion in Jaffe et al., 1995). Compliance with stringent environmental regulation is commonly associated with a significant burden for polluting firms or sectors and, as a consequence, with reduced profitability. This is suggested by microeconomic theory, where environmental regulation can be modeled as a cost factor (e.g., Ebert, 2006), and supported by many empirical studies (e.g., Gray, 1987, Ederington and Minier, 2003, or Shadbegian and Gray, 2005). However, for the particular case of an emission trading scheme with free allocation of emission rights (grandfathering) – a case that is comparable to the first phase of the EU ETS – economic theory suggests that covered firms can even realize additional producer rents due to the scheme if they are able to pass on carbon costs to their consumers (Sijm et al., 2006). This, however, should be the case only for sectors that face, on the one hand, low exposure to – particularly international – competition and, on the other hand, low elasticities of demand. Apart from that, the controversial Porter hypothesis questions the negative economic consequences of environmental policy, suggesting that stringent environmental regulation provides incentives for companies to innovate and that these innovations can stimulate economic growth and competitiveness of the regulated country (see Porter and van der Linde, 1995, for a characterization of the hypothesis, and Palmer et al., 1995, for a profound critique).

In terms of evaluating the economic effects of recent climate policy, the existing literature is dominated by the application of theoretical and numerical models. In this respect, economic impacts of environmental policy under different regulatory designs have been assessed. Analyses mainly relate to (the flexibility of) the geographic location (Anger et al., 2007, Welsch and Lokhov, forthcoming) and the time (Toman et al., 1999, Böhringer, 2003) of emission reduction as well as to the type of GHG to be reduced (Böhringer et al., 2006). Another aspect analyzed is the implementation of ETS with respect to the allocation of emission allowances (Böhringer and Lange, 2005a, b). Against this background, this thesis aims at complementing these theoretical and numerical analyses mainly by providing empirical evidence on the relationship between environmental policy and the economic performance. The assessment of environmental regulation focuses on – but is not restricted to – climate policy issues. As empirical work in this field is practically inexistent, the application if econometric techniques to newly available data sets that give information about implemented climate policies seems promising.

Energy prices undisputedly represent costs for energy using firms. Concerns that energy price hikes would consequently slow down economic growth, leading to increased unemployment and reduced profits, have been expressed since the 1970s, but particularly in recent years (Tanaka, 2008). However, this does not imply that all economies face the same threats in times of energy crises – neither do all of their sectors (Jones et al., 2004). At the national level, highly energy-efficient economies such as Germany are assumed to be only moderately affected by energy price booms (Schmidt and Zimmermann, 2007). From a sectoral perspective, the energy industry is even claimed gaining from energy price booms: Such price hikes imply that the output prices of this industry rise while demand elasticities of energy use are relatively low (Boyer and Filion, 2007). Energy intensive industries, in contrast, face a major input cost shock in times of energy crises.

Generally, not only energy prices as such, but also price volatility shocks are highly relevant from an economic point of view (Ferderer, 1996, Sadorsky, 1999). Many authors such as Sauter and Awerbuch (2003) even argue that since “the 1980s, oil price volatility is more significant in its effects on economic activity than the oil price level”. The economic rationale for this paramount importance of volatility is the fact that it, e.g., according to Markowitz’ (1952) seminal paper, represents risk and uncertainty inherent in the respective market. However, energy price volatility is omitted in most of the previous analyses. Therefore, this thesis explicitly covers not only the economic effects of energy price changes, but also of energy price volatility. Moreover, taking into account the uncertainty concerning the construction of adequate energy price shock variables (Mork, 1989, Hooker, 1996, or Hamilton, 1996), it aims at providing robust evidence on the relationship between energy markets and economic performance. Since most of the existing research in empirical energy economics has been carried out for the U.S. and Canada, this thesis concentrates on Germany, Europe’s biggest economy, and Europe as a whole, where evidence on employment and stock market effects of energy market shocks is scarce or even completely missing.

From a methodological point of view, this thesis is based mainly on the application of modern econometric techniques that are employed in order to test theoretical propositions and hypotheses described in each chapter. One major challenge of empirical approaches in general is the identification of causal effects. Due to possible simultaneous developments, this is particularly difficult when cross-sectional data are used (e.g., Börsch-Supan and Köke, 2002). In this regars, further difficulties arise in analyses of the relationship between environmental action, environmental regulation, and economic performance. Widely used indicators of stringency of environmental regulation such as abatement costs as well as indicators of environmental performance such as "green" investment may not only affect, but also be influenced by the economic performance of firms or sectors. As a remedy to this problem, in this dissertation such simultaneous or even reverse causal relations are modeled within multi-equation frameworks based on the instrumental variable approach. Moreover, where possible this thesis makes use of the time dimension of the respective data series used that naturally reduces causality problems and that allows for modelling a time lag between cause and effect.

Further emphasis is placed on the peculiarities of financial markets. This is due to the fact that the energy markets as one segment of international financial markets are the most relevant data source for empirical analyses in energy economics. In addition, stock prices representing discounted future cash flows and therefore the value of corporations as a widely accepted indicator of the economic performance of the respective companies (Fama, 1970), are analyzed in selected chapters of this thesis. This focus on financial markets, on the one hand, calls for an adequate representation of financial market characteristics such as dynamics of prices and of price volatility (so-called volatility clusters) as well as financial market shocks within the empirical approach. This is, for example, done by modeling financial time series using approaches of the GARCH (Generalized Autoregressive Conditional Heteroskedasticity; Bollerslev, 1998) class and VAR (vector autoregression) models (Sims, 1980). On the other hand, with volatility being economically interpreted as an indicator of market risk and uncertainty (e.g., Markowitz, 1952), this emphasis on financial markets allows for the illustration of economic effects of, e.g., energy market risk and uncertainty.

The dissertation comprises a selection of essays on the relationship between, on the one hand, environmental regulation as well as energy market developments, and, on the other hand, economic performance of firms and sectors. Each chapter provides a stand-alone analysis featuring an introduction to the research question of interest, the contribution to the existing literature and the methodological approach. The majority of essays has been written in collaboration with co-authors and prepared for the submission to academic journals.

In the chapters 2.1. to 2.3. of the thesis, the relationship between environmental regulation and economic performance is tackled from different perspectives. Within the framework of a political-economy analysis of allowance allocation in the EU Emission Trading Scheme, chapter 2.1. analyzes whether economic strength can, via lobby power, lead to a comparably low regulatory burden of any sector. For this purpose, a common-agency model is developed that predicts distributional and efficiency aspects of lobby influence on allowance allocation within an emission trading scheme. An empirical analysis tests the theoretical predictions for a large cross-section of German ETS firms, assessing the allowance allocation within the first phase of EU ETS. Furthermore, the analysis addresses the question whether lobbying induces a deviation of EU allowance allocation from its economically efficient level. In chapter 2.2. and complementary to the political-economy analysis, the role of the EU Emission Trading Scheme for firm performance and employment is examined. An overview of relative allowance allocation within the EU ETS as well as an econometric analysis of a large sample of firms covered by the scheme is provided. Data from the Community Independent Transaction Log (CITL) give insights into the EU Emission Allowance long / short positions at the country level in the first phase of EU ETS. An econometric analysis using a large and unique cross-sectional dataset for German ETS companies assesses whether relative allowance allocation has had significant impact on performance and employment of regulated German companies.

Chapter 2.3. of this thesis addresses economic impacts of environmental action that is not necessarily motivated by environmental regulation itself. This analysis is based on the observation that many firms have started to show environmental commitment that may even go beyond legal requirements. A production function approach accounting for environmental investment as well as environmental and energy expenditures as capital inputs provides the basis for this inquiry. In addition, an empirical analysis making use of a panel dataset of the German manufacturing industry between 1996 and 2002 is moreover provided. The investigation focuses on the contribution of environmental investment as well as environmental and energy expenditures to production growth. Even if such investment and expenditures may not necessarily be regulation-driven, environmental policy may, depending on the instrument choice, create these measures. Therefore, the analysis may provide reference for the design of such policies if their goal is not only the protection of the environment, but also compatibility with economic goals such as productivity.

Chapters 3.1. to 3.3. of this thesis contain different approaches in measuring effects of energy market developments on economic performance. Linking the topics of energy markets and environmental regulation, chapter 3.1. assesses the economic effects of EU carbon market developments. More precisely, EU Emission Allowance price effects on stock prices as an indicator of expected future cash flows and therefore of economic performance of the respective corporations are analyzed. The focus of the analysis is on stocks of electricity companies, the most dominant players within the EU ETS. The assessment considers possible asymmetric stock market reactions to EUA price changes. Within the framework of a panel data analysis, carbon market effects are assessed with regard to different aspects: The analysis focuses on peculiarities regarding the period of EUA market shock in early 2006, and on the role of the national electricity market in which the respective electricity corporations operate. Finally, against the background of high volatility of the EUA price since the establishment of the EU ETS, the inquiry covers possible stock market reactions to EUA volatility as a proxy of carbon market risk.

Relaxing the focus on EUA prices, chapter 3.2. deals more generally with economic effects of resource price movements. In the light of recent energy market turbulences, an assessment of the relationship between energy market developments and the performance of European energy stocks is conducted. While the effect of energy prices on stocks of, e.g., U.S. and Canadian energy corporations has already been investigated, the energy to stock market relationship for Europe is unexplored to date. Against this background, the chapter assesses the effects of oil, gas and coal market movements on the values of Eurozone energy companies. Complementary to the existing literature on stock market performance of energy corporations that is limited to the analysis of energy prices, the role of energy market volatility effects for the stock market is assessed explicitly. Furthermore, in order to avoid errors-in-variables problems due to the inclusion of systematic (forecastable) volatility variables, a simple methodology to compute unexpected energy volatility is developed and applied in the empirical analysis.

Finally, in chapter 3.3. the macroeconomic impacts of oil price developments are covered. For the German economy, the fear of an oil price induced economic slowdown and a subsequent rise in unemployment is strong. As the German unemployment rate has been rising since the 1970s until recently, unemployment has been a severe problem for the German economy even during recent economic boom phases. In this light, unemployment in Germany as an important outcome variable of the economic performance of German firms and sectors is analyzed with a focus on oil market impacts. A vector autoregression (VAR) approach using monthly data provides evidence for the oil to macroeconomy relationship in Germany since 1973. Against the background of uncertainty related to the construction of an adequate oil variable, three different specifications based on different oil shock computations are provided. In addition, claims that the oil to macroeconomy relationship has weakened since the 1980s are empirically tested using a restricted sample period for post-unification Germany.

All in all, the findings presented in this thesis do not lend support to the controversial Porter hypothesis that suggests that environmental regulation may stimulate economic growth and competitiveness. However, the thesis shows that the economic impacts of recent EU environmental policy which is aimed at combating man-made climate change have been modest at most. Consistent with economic theory reasoning, the low stringency of recently adopted regulatory measures is identified as one important driver of this result. Moreover, results presented in this thesis also indicate the importance of political economy mechanisms for the design of EU ETS and of environmental regulation in general. These mechanisms are shown to be a driver of the low stringency and, consequently, of the small economic effects of EU ETS during its first phase. Besides, the thesis highlights the role of investment stimulation if the goal of environmental regulation is not only the protection of the environment, but also compatibility with economic goals such as productivity.

In addition, this thesis provides new insights into the importance of energy market developments for the economic performance of firms and sectors. In this respect, a first analysis of the stock market effects of the EU Emission Allowance market shows the relevance of the EU ETS to the financial market performance of European electricity generators. Besides, this thesis demonstrates the paramount importance of oil market developments to the economy as a whole. The thesis suggests that amongst all natural resources, oil is the most relevant one to the pricing of Eurozone energy stocks. It also shows that besides oil prices, oil volatility plays an important role for stock market development. Finally, the thesis highlights the relevance of oil market developments to the economy, in demonstrating that unemployment in Germany is strongly affected by oil price shocks. Apart from illustrating the importance of constructing adequate oil shock variables, the thesis particularly opposes claims that the German oil to macroeconomy relationship has weakened since the 1980s. This suggests that an emerging oil crisis would have serious effects on the German economy, implying a significant increase in unemployment.

The thesis is structured as follows: Following this introduction, the chapters 2.1. to 2.3. assess the relationship between environmental regulation and economic performance. Here, chapter 2.1. presents a combined theoretical and empirical political-economy analysis of allowance allocation in the EU Emission Trading Scheme. Focusing on relative allowance allocation, chapter 2.2. analyzes the impacts of EU emission regulation on firm revenues and employment. Chapter 2.3. assesses the role of environment- and energy related expenditures as well as of environmental investment for production in the German manufacturing industry. The chapters 3.1. to 3.3. tackle the relationship between energy market developments and economic performance. Here, economic effects of the market for EU Emission Allowances are described in chapter 3.1. In chapter 3.2., the link between resource prices and resource price volatility on the one hand, and stock market performance of the European energy industry on the other hand, is assessed. Within the framework of a vector autoregression, chapter 3.3. provides an in-depth analysis of oil price effects on unemployment in Germany. Summing up the main findings of the thesis, chapter 4 concludes.

2. Environmental Regulation and Economic Performance

2.1. Public Interest vs. Interest Groups: Allowance Allocation in the EU Emission Trading Scheme[1]

2.1.1. Introduction

The central instrument of Europe's current climate policy is the EU Emission Trading Scheme (EU ETS) which was established in 2005 and entered its second trading period in 2008 (EU, 2003). Aiming at emission reductions at least cost, the EU ETS was celebrated as a "new grand policy experiment" already before its implementation (Kruger and Pizer, 2004). However, the actual implementation of the EU ETS suggests that due to a generous allowance allocation to covered industries, the induced emission abatement has been rather limited at least in the first phase (from 2005 to 2007). This chapter investigates whether the permit allocation design in the EU ETS is representing public interest in terms of economic efficiency or can be explained by the presence of sectoral interest groups.

The outspoken objective of the EU ETS is to achieve Europe's greenhouse gas emission reduction commitments under the Kyoto Protocol at minimal cost through the tradability of emission rights (or likewise abatement efforts) across major emission sources. In its first two phases, the EU ETS covers more than 10,000 energy-intensive installations that belong to mainly five industrial sectors: power, heat and steam generation; oil refineries; iron and steel production; mineral industries (e.g., cement, lime and glass); pulp and paper plants (EU, 2003). During these two phases, each Member State is obligated to set up an annual National Allocation Plan (NAP) where it defines the cap on emission allowances for sectors (installations) included in the trading scheme and the specific allocation rule for grandfathering, i.e., the entitlement with free pollution rights based on historical emissions.

[1] This chapter is based on the research paper "Public Interest vs. Interest Groups: Allowance Allocation in the EU Emission Trading Scheme", co-authored by Niels Anger, Christoph Böhringer and Ulrich Oberndorfer (Correspondence is to all authors).

In this chapter we present a political-economy analysis of allowance allocation in the EU ETS. We develop a stylized theoretical framework for the allocation of emission allowances in a cap and trade system, where the regulator values political contributions from sectoral interest groups when determining the stringency of allowance allocation. In the stylized model, the regulator implements an inefficiently high level of allowance allocation, thereby shifting the regulatory burden to those sectors excluded from the trading system. Within the emission trading scheme, the distribution of permits is biased in favor of those sub-sectors featuring more powerful lobby groups. However, the impact of lobbying depends on the level of sub-sectoral emissions and the government's weight on political contributions. We test the predictions of our analytical model with an empirical analysis on the political-economy determinants of permit allocation in the EU ETS for a large cross section of regulated firms in Germany. Our results suggest that the allocation of emission allowances has been partly driven by sectoral interest groups: large carbon emitters that were heavily exposed to emission regulation and simultaneously represented by powerful interest groups received higher levels of emission allowances. The combination of lobbying for permits and high emitting activity thus affects the distribution of allowances, but also leads to a deviation of the observed permit allocation from its economically efficient level.

Standard economic theory suggests that the introduction of market-based instruments of environmental policy – such as (uniform) emission taxes or (auctioned) tradable emission allowances – can generate cost-efficient emission reductions by equalizing marginal abatement costs across polluters. Against this background, the mainly free allowance allocation in the EU ETS has been criticized for its generous and differential treatment of regulated industries, as well as its incomplete sectoral coverage. While a number of studies on the economic impacts of EU ETS regulation indicate the existence of such a burden shifting (see Böhringer et al., 2005; Kallbekken, 2005; or Peterson, 2006), its rationale has remained implicit to date.

The lacking welfare-economic explanation for the observed regulatory design represents the initiation of the political-economy analysis of environmental policy. Building on Olson's (1965) theory of the formation and power of interest groups, general positive theories have presented alternative approaches to study the political-economy determinants of policy outcomes (see Oates and Portney, 2003 for the context of environmental policy). In particular, the literature emphasizes the exchange of truthful information between interest groups and policy makers as a channel of influence, upon which politicians base their decisions (Grossman and Helpman, 2001; Naevdal and Brazee, 2000; Potters and van Winden, 1992). Previous studies on political-economy determinants of environmental taxation include Frederiksson (1997) and Aidt (1997, 1998) who investigate the implications of international competition and revenue recycling for the design of environmental tax reforms.

In this context, Anger et al. (2006) provide a first combined theoretical and empirical analysis of the role of interest groups in environmental tax differentiation. They show that a sectoral differentiation of green tax reforms is not only determined by the activity of lobby groups favoring reduced environmental tax rates, but also by the groups' interest in revenue rebates to labor. The existing political-economy literature on emission regulation by tradable permits focuses on the choice between free permit allocation based on historic emission levels and auctioning of pollution rights. Hanoteau (2005) theoretically shows that in the presence of interest groups an environmental regulator prefers a free allocation of permits over auctioning, and relaxes the underlying emission cap. Likewise, Markussen and Svendsen (2005) argue that dominant industrial lobby groups influenced the corresponding EU ETS directive towards a grandfathered allocation rule. An empirical study by Hanoteau (2003) suggests that political influence by means of financial campaign contributions affected the distribution of permits within the U.S. sulphur emission trading system. Existing empirical studies on EU ETS have focused on the formation of the EU allowance price (Benz and Trück, forthcoming) and its economic effects (Oberndorfer, forthcoming).

The present chapter tries to complement the political-economy analysis of the EU ETS with an explicit and combined theoretical and empirical assessment of the role of interest groups in the EU emission trading system by providing a twofold contribution: First, we develop a stylized *common-agency* framework for the allocation of emission allowances in a cap and trade system. Second, we provide an empirical analysis on the political-economy determinants of permit allocation in the EU ETS for a large cross section of regulated firms in Germany. To our best knowledge, we thereby provide the first theoretical and empirical political-economy assessment of EU emission allowance allocation.

The remainder of this chapter is structured as follows. In section 2.1.2, we develop a political-economy framework for the allocation of emission allowances in a cap and trade system. In section 2.1.3., we present an empirical analysis of the determinants of permit allocation in the EU ETS. In section 2.1.4., we conclude.

2.1.2. Theoretical Framework

In this section we present a stylized analytical framework of the role of interest groups for the allocation of emission allowances in a cap and trade system. The model is structured as a *common-agency* problem, in which principals (interest groups) aim to induce an action from an agent (the government). As introduced by Grossman and Helpman (1994) in the context of international trade, lobby groups may influence political decisions – here: the stringency of allowance allocation – if the government does not only care about social welfare but also values political contributions by interest groups.

In order to analyze the firm's behavior on the emission market, we build on the one-sector partial equilibrium model by Böhringer and Lange (2005a) assessing emission-based allocation rules in cap-and-trade systems. In our model we consider an emission-constrained economy with two aggregate production sectors $i \in \{ets, nets\}$, one of which is regulated by an emission trading scheme (*ets*) while the other is excluded from the scheme (*nets*). Sectoral emissions e_i are the product of the emission rate (or intensity) μ_i and the output level q_i ($e_i = \mu_i q_i$). Marginal production costs $c(\cdot)$ are constant in output, decreasing in emission rate ($c(\mu) \geq 0,\ c'(\mu) < 0,\ c''(\mu) > 0$). Inverse demand for output $P(q)$ is decreasing in q and differentiable.

In order to fulfill a given economy-wide emission target $\overline{E}$ (as committed to, e.g., under the Kyoto Protocol) the national government implements a hybrid system of emission regulation: tradable emission allowances for the covered *ets* sector and emission taxation for the remaining (*nets*) sector of the economy. Motivated by the EU Emission Trading Scheme, emission permits are freely allocated to the *ets* sector based on pollution levels, i.e., emission rates and output levels. The stringency of emission regulation is represented by an *allocation factor* α that denotes the fraction of benchmark emissions freely allocated as allowances, so that the sectoral permit allocation equals $\alpha\mu_{ets}q_{ets}$. Emission allowances are tradable internationally at an exogenous permit price σ. For the *nets* sector, the regulator allows the remaining emission budget of $\overline{E} - \alpha\mu_{ets}q_{ets}$ in order to fulfill the economy-wide target.

The political process involves an incumbent government (i.e., an environmental regulator) and an industrial lobby group that represents sectoral (i.e., firms') interests. Motivated by current EU emission regulation, we assume the formation of interest groups only for the covered *ets* sector, while the *nets* industry does not feature lobbying activities. We base this assumption on the fact that the EU Emission Trading Scheme covers mainly energy-intensive industries and represents the dominant instrument of environmental regulation for these sectors. In contrast, the remaining segments of EU economies (e.g., the transport sector or households) are subject to a more diverse set of environmental policy instruments (such as energy taxes or subsidies). Besides their single-targeted motive of lobbying for free emission allowances, energy-intensive industries also feature a relatively high degree of concentration, which according to Olson (1965) should enable a better organization of interests by overcoming the problem of free-riding.

Motivated by Grossman and Helpman (1994), in the model the lobby group can offer a set of political contributions $K_{ets}(\alpha)$ to the government depending on the envisaged policy decision. In our context, sectoral contributions are thus a function of the allocation factor. Political contributions may either represent monetary campaign donations by interest groups or a more general form of political support, such as information transfer between interest groups and policy makers (Grossman and Helpman, 2001). In our analysis we abstract from interest group formation and behavior and thus focus on the political equilibrium in which lobby contributions $K_{ets}(\alpha)$ reflect the true preferences of interest groups: a marginal change in the lobby contribution for a marginal policy change corresponds to the effect of the policy change on the group's welfare.

Against this political-economy background, aggregate profit maximization in sector *ets* (firms are price taker on the goods and emission market), including the costs or revenues from emission trading as well as efforts for political contributions, is given as:

$$\max_{q_{ets},\mu_{ets}} \pi_{ets} = p_{ets}q_{ets} - c_{ets}(\mu_{ets})q_{ets} - \sigma(1-\alpha)\mu_{ets}q_{ets} - K_{ets}(\alpha).$$

Likewise, aggregate profit maximization in the *nets* sector which is regulated by an emission tax (firms are price taker on the goods market) is given as:

$$\max_{q_{nets},\mu_{nets}} \pi_{nets} = p_{nets}q_{nets} - c_{nets}(\mu_{nets})q_{nets} - \tau\mu_{nets}q_{nets}.$$

The corresponding first-order conditions of the firm can be found in Appendix A.1. Social welfare (gross of political contributions) is composed of aggregate consumer and producer surplus including the costs or revenues from international emission trading[2]:

[2] Note that emission tax revenues are assumed to be redistributed on a lump-sum basis, so that they emission taxation does not enter the welfare function.

$$W = \sum_i \int_0^{q_i} P_i(r_i)dr_i - \sum_i c_i(\mu_i)q_i - \sigma(1-\alpha)\mu_{ets}q_{ets} .$$

The Political Equilibrium

The problem of the incumbent government is to maximize its political support. To this aim it values the level of political contributions by interest groups besides social welfare (the latter presuming that a higher standard of living increases the chances for reelection). The regulator thus maximizes a weighted sum of contributions and welfare given an environmental constraint (i.e., the total emission target) by choosing the allocation factor for the *ets* sector and the emission tax for the *nets* industry:

$$\max_{\alpha,\tau} G(\alpha,\tau) = \theta K_{ets}(\alpha) + (1-\theta)W \quad \text{s.t.} \quad \overline{E} = \alpha\mu_{ets}q_{ets} + \mu_{nets}q_{nets} .$$

In this framework, the government maximizes a social-welfare function that weights sectors represented by a lobby group with the weight of 1 and the remaining members of society with the smaller weight of $1-\theta$. Obviously, the higher the value of θ, the higher the regulator values political contributions by interest groups in comparison to social welfare (the regulator fully ignores lobby contributions in the extreme case of θ equal to zero, whereas she only cares about political contributions for θ =1). We restrict the value of θ to 0< θ <1, abstracting from negative weights on social welfare within government's objective function.

In the following, we analyze the regulatory behavior of the government in terms of allowance allocation and emission taxation. Denoting the Lagrange multiplier as λ yields the following Lagrange function for the government:

$$L = G(\alpha,\tau) + \lambda(\overline{E} - \alpha\mu_{ets}q_{ets} - \mu_{nets}q_{nets}) .$$

The first-order conditions of the firm as well as the environmental constraint imply that μ_{ets} and q_{ets} are implicit functions of α. Derivation of the government's objective function w.r.t. the allocation factor thus gives:

$$0=\frac{\partial L}{\partial \alpha}=\theta K_{ets}'(\alpha)+(1-\theta)\left\{\left[p_{ets}-c_{ets}(\mu_{ets})\right]\frac{\partial q_{ets}}{\partial \alpha}-\left[c_{ets}'(\mu_{ets})+\sigma(1-\alpha)\right]\frac{\partial \mu_{ets}}{\partial \alpha}q_{ets}-\sigma(1-\alpha)\frac{\partial q_{ets}}{\partial \alpha}\mu_{ets}+\sigma\mu_{ets}q_{ets}\right\}$$
$$-\lambda\left[\mu_{ets}q_{ets}+\alpha\left(\frac{\partial q_{ets}}{\partial \alpha}\mu_{ets}+\frac{\partial \mu_{ets}}{\partial \alpha}q_{ets}\right)\right]. \qquad (1)$$

Using the firm's first-order conditions (13) and (14) yields the political equilibrium in terms of the allocation factor for the *ets* sector:

$$\alpha=\frac{\theta K_{ets}'(\alpha)+\left[(1-\theta)\sigma-\lambda\right]\mu_{ets}q_{ets}}{\lambda\left(\frac{\partial q_{ets}}{\partial \alpha}\mu_{ets}+\frac{\partial \mu_{ets}}{\partial \alpha}q_{ets}\right)}. \qquad (2)$$

Given that all determinants on the right hand side of condition (2) are positive and 0< θ <1, it shows that while the impacts of the government's weight on political contributions relative to social welfare, the emission rate and the output level are indeterminate, the allocation factor is increasing both in marginal political contributions by the lobby group and the international permit price. Condition (2) thus suggests that if the *ets* sector's interest group is able to increase political contributions to a larger extent for a higher allocation factor (i.e., if the lobby group is sufficiently strong), the regulator implements a higher allocation factor. However, the impact of lobbying depends on the government's weight on political contributions. Moreover, α is decreasing in the shadow-price of the environmental constraint and the sensitivity of sectoral output and emission to the allocation factor.[3]

Proposition 1: In the political equilibrium, the allocation factor chosen by the government is the larger, the lower the shadow-price of the environmental constraint and the more powerful the sectoral lobby group. The impact of lobbying depends on the government's valuation of political contributions by interest groups.

[3] Note that conditions (13) and (14) in the Appendix imply that $\partial q_s / \partial \alpha > 0$ and $\partial \mu_s / \partial \alpha > 0$.

At this stage, we can distinguish between two extreme cases: the government fully ignoring lobby contributions and only maximizing social welfare (θ =0), and the regulator valuing only political contributions by interest groups in its objective function (θ =1). In the first case, condition (2) translates into the welfare-maximizing allocation factor:

$$\alpha^W = \frac{(\sigma - \lambda)\mu_{ets} q_{ets}}{\lambda\left(\frac{\partial q_{ets}}{\partial \alpha}\mu_{ets} + \frac{\partial \mu_{ets}}{\partial \alpha} q_{ets}\right)}. \tag{3}$$

In the second case of θ =1, we arrive at the regulation that maximizes political contributions for the government:

$$\alpha^{PC} = \frac{K_{ets}'(\alpha) - \lambda \mu_{ets} q_{ets}}{\lambda\left(\frac{\partial q_{ets}}{\partial \alpha}\mu_{ets} + \frac{\partial \mu_{ets}}{\partial \alpha} q_{ets}\right)}. \tag{4}$$

The regulatory behavior of the government in terms of emission taxation on the *nets* sector can be derived analogously to the allocation factor. The first-order conditions of the firm and the environmental constraint imply that μ_{nets} and q_{nets} are implicit functions of τ. Derivation of the government's objective function w.r.t. the emission tax thus gives:

$$0 = \frac{\partial L}{\partial \tau} = (1-\theta)\left\{\left[p_{nets} - c_{nets}(\mu_{nets})\right]\frac{\partial q_{nets}}{\partial \tau} - c_{nets}'(\mu_{nets})\frac{\partial \mu_{nets}}{\partial \tau} q_{nets}\right\} - \lambda\left(\frac{\partial q_{nets}}{\partial \tau}\mu_{nets} + \frac{\partial \mu_{nets}}{\partial \tau} q_{nets}\right).$$

Using the firm's first-order conditions (15) and (16) yields the political equilibrium in terms of the emission tax on the *nets* sector:

$$\tau = \frac{\lambda}{1-\theta}. \tag{5}$$

The resulting tax rate equals the shadow price of the environmental constraint, adjusted by the government's weight on political contributions relative to social welfare. As for regulation in the *ets* sector, we can distinguish between two extreme cases: the government fully ignoring lobby contributions and only maximizing social welfare (θ=0), and the regulator valuing only political contributions by interest groups in its objective function (θ=1). In the first case, condition (5) translates into the welfare-maximizing emission tax:

$$\tau^W = \lambda . \qquad (6)$$

Efficient emission regulation thus requires that the tax rate equals the shadow price of the environmental constraint. In contrast, once the government values political contributions by interest groups from the *ets* sector (θ>0), condition (5) implies that the emission tax on the *nets* sector is increased to an inefficiently high level. In the extreme case of θ=1, a regulator only valuing political contributions implements an emission tax of $\tau^{PC} \to \infty$ on the *nets* sector in order to maximize its political support from the *ets* sector.

Efficiency and Distributional Implications of Lobbying

For a given λ, condition (5) suggests that a higher government's weight on political contributions relative to social welfare increases the emission tax on the *nets* sector. For a given economy-wide emission target $\overline{E}$, the associated lower emissions of the *nets* sector decrease the shadow price of the environmental constraint λ. Following Proposition 1, the lower the level of λ, the higher the allocation factor, and the lower the stringency of regulation in the *ets* sector. The simultaneous (indirect) effect decreasing the emission tax in condition (5) attenuates the previous (direct) increasing effect on the tax rate. However, the positive impact of an increase in θ on taxation is not reversed, as in the environmental constraint a higher allocation factor in the *ets* sector necessarily implies lower emissions of the *nets* sector in order to reach a given emission target, i.e., a higher tax level.

We conclude that if the government values political contributions by interest groups (θ >0), it implements an emission tax on the *nets* sector and a corresponding allocation factor for the *ets* sector which exceed the respective levels of an efficient instrument mix (τ^W , α^W).

Proposition 2: The government's valuation of political contributions by interest groups from sectors covered by the emission trading scheme leads to inefficiently high levels of emission taxation and allowance allocation, thereby shifting the regulatory burden from covered sectors to the remaining industries of the economy.

In the following, we analyze the sub-sectoral distribution of allocated allowances within the emission trading scheme. To this aim we describe the *ets* sector as being composed of *s = 1…S* sub-sectors, each of which is represented by an industrial lobby group. Political contributions at the sub-sectoral level depend on a sub-sectoral allocation factor and are given by $K_s(\alpha_s)$. The political equilibrium within the *ets* sector can then be derived analogously to condition (2) by profit maximization in the respective sub-sectors and the political-support maximizing behavior of the government on the aggregate sectoral level.

We now analyze comparative statics in the resulting political equilibrium. Considering two exemplary sub-sectors 1 and 2, the corresponding allocation factors are given by:

$$\alpha_1 > \alpha_2 \iff \left[\frac{\theta K_1'(\alpha_1) + \left[(1-\theta)\sigma - \lambda\right]\mu_1 q_1}{\lambda\left(\frac{\partial q_1}{\partial \alpha_1}\mu_1 + \frac{\partial \mu_1}{\partial \alpha_1} q_1\right)} \right] > \left[\frac{\theta K_2'(\alpha_2) + \left[(1-\theta)\sigma - \lambda\right]\mu_2 q_2}{\lambda\left(\frac{\partial q_2}{\partial \alpha_2}\mu_2 + \frac{\partial \mu_2}{\partial \alpha_2} q_2\right)} \right]. \qquad (7)$$

For 0< θ <1, the sub-sectoral allocation factor is – ceteris paribus – higher and thus regulatory stringency lower for sub-sectors of the emission trading scheme featuring: (i) higher marginal contributions of sub-sectoral interest groups (ii) and lower sensitivities of sectoral output levels and emission rates to the allocation factor. In contrast, the effects of different sectoral emission rates and output levels are indeterminate. Result (i) implies that sub-sectors represented by lobby groups which are able to increase political contributions to a larger extent for a higher sub-sectoral allocation factor (i.e., that are more powerful) face a lower regulatory burden.

Denoting $e_s = \mu_s q_s$ as sub-sectoral emissions and $A_s = \alpha_s \mu_s q_s$ as the level of allowance allocation, condition (7) translates into:

$$A_1 > A_2 \;\Leftrightarrow\; \left[\frac{\theta K_1'(\alpha_1)e_1 + [(1-\theta)\sigma - \lambda]e_1^2}{\lambda\left(\frac{\partial q_1}{\partial \alpha_1}\mu_1 + \frac{\partial \mu_1}{\partial \alpha_1}q_1\right)}\right] > \left[\frac{\theta K_2'(\alpha_2)e_2 + [(1-\theta)\sigma - \lambda]e_2^2}{\lambda\left(\frac{\partial q_2}{\partial \alpha_2}\mu_2 + \frac{\partial \mu_2}{\partial \alpha_2}q_2\right)}\right]. \qquad (8)$$

Our theoretical framework thus predicts that, ceteris paribus, firms belonging to industries that are represented by more powerful lobby groups also receive a higher *level* of allowance allocation. However, marginal political contributions do not have a stand-alone effect on absolute permit allocation: condition (8) suggests that – unlike in the case of the allocation factor – the impact of lobbying depends on the level of sub-sectoral emissions besides the government's weight on political contributions (as shown by condition (2)). Furthermore, quadratic emissions levels play a (yet indeterminate) role for the implemented allowance allocation.

Proposition 3: In an emission trading scheme with several sub-sectors, those industries featuring higher lobbying power but lower sensitivities of sectoral output and emissions to the allocation factor receive a higher level of allowance allocation. The role of lobbying for the sub-sectoral distribution of allowances depends on the level of sub-sectoral emissions.

In the next section, we will test our theoretical Propositions 2 and 3 by means of an empirical analysis on the determinants of allowance allocation in the EU Emission Trading Scheme.

2.1.3. Empirical Analysis for Germany

In this section we present an empirical assessment of the determinants of EU ETS emission allowance allocation at the German firm level in order to test our central theoretical predictions of the previous section. In its first trading phase, the EU ETS exclusively covers installations in energy-intensive sectors (such as electricity, iron and steel, or paper and pulp), while the remaining industries of EU economies (such as households or the transport sector) have to be regulated by complementary abatement policies in order to meet the countries' overall emission targets. The EU ETS prescribes the (in the two first phases mainly free) allocation of emission allowances to installations according to historic levels by means of National Allocation Plans (NAPs) of the respective Member States, specifying an overall cap in emissions for the covered sectors. Our regression analysis particularly aims at investigating the role of interest groups for the allowance allocation design of the first trading phase of the EU Emission Trading Scheme. It focuses both on the question whether lobbying may have induced a deviation of actual allowance allocation from its economically efficient level (as predicted by theoretical Proposition 2) and on the distributional impacts of lobbying among regulated firms (as predicted by Proposition 3).

Data and Variables

For the empirical analysis, we use a unique economic and environmental cross-sectional data set for Germany at the firm level. It is a data compilation based on three different sources: First, we employ the CREDITREFORM database, an economic database of German firms, from which we selected those firms regulated by the EU ETS (see Appendix A.2 for details of the data base). In this respect, it should be noted that Germany is the most important country within the EU ETS in terms of carbon emissions, its companies representing roughly a quarter of all allowances allocated. Second, we make use of a data set on verified emissions and EU ETS allowances allocated in 2005 that is publicly available from the EU Community Independent Transaction Log (EU, 2007). Given the fact that the Community Transaction Log contains information at the installation level only, emission and allowance data were aggregated at the firm level. Third, for our political-economy analysis we integrated data on representatives of German industrial associations. This interest group data refers to the subsectoral level and was generated from a telephone survey conducted in 2004 (see further down). All in all, data including 175 German firms could be consistently compiled.

Important variables related to the political process of allowance allocation in the EU ETS are the number of allowances allocated to regulated firms as well as the so-called allocation factor (allocation relative to baseline emissions) and its deviation from an economically efficient level – all of which representing the governmental decision of emission regulation in the EU ETS. Our dataset consists of allowance allocation and emission data at the firm level, both for the year 2005. Another central variable for our analysis is the number of sectoral lobby representatives, measuring potential political support provided by sectoral interest groups (see below). Our data basis is completed by information on employment (i.e., the number of employees) at the firm level, both referring to 2004, the year of decision concerning allowance allocation for the first EU ETS phase as well as to preceding years (2000-2002). Moreover, we employ interaction terms between and nonlinear transformations of selected variables: In addition to verified emissions and the lobby variable we can include squared verified emissions, as well as interaction terms of the lobby variable with verified emissions and employment as explanatory variables for the regression analysis. The importance both of squared emission levels and the interaction term between the emission level and the lobby variable have been laid out in our theoretical framework. The corresponding descriptive statistics are presented in Table A. 1 in the appendix. In the following, we describe the variables of our dataset in greater detail.

Table A. 1 shows that our data set includes a broad firm interval of verified emissions and allowances allocated, e.g., allowances per firm ranging from 272 up to 346.000.000 tons of CO_2-equivalent. Regarding the relationship between the number of allowances allocated and the verified emissions in 2005, the table suggests that the number of allocated allowances is relatively high compared to the level of 2005 emissions. In our German sample, the (firm) mean of allowances allocated is 533645.9 against 511996.5 (tons of CO_2-equivalent) of verified emissions, which means that in 2005 allowance allocation to regulated firms exceeded actual emissions by about 30 per cent.[4] This implies that the sample mean of the allocation factor (defined as the allowances allocated divided by the verified emissions) amounts to 1.3. Given the EU's emission reduction commitment under the Kyoto protocol and Germany's corresponding reduction target of 21 percent below 1990 emissions, the high allocation factor in our sample stands in clear contrast to an efficient allowance allocation. In this context, numerical simulations provided, e.g., by Böhringer et al. (2005) suggest an economically efficient allocation factor – ensuring equalized marginal abatement costs across all sectors of the economy – amounting to 0.903 for Germany under the Kyoto Protocol. This allocation factor ensures that the national emission budget is divided efficiently between those sectors covered by the ETS and the remaining, non-covered sectors. In order to account for such efficiency problems, we construct a variable proxying the absolute deviation of the observed firm-level allowance allocation to the efficient allocation. We calculate this variable as the actual allowance allocation less the efficient one. Given the unavailability of ex-ante emission data (i.e., from 2004 or earlier), the latter is derived by multiplying the optimal allocation factor (0.903) with verified emissions. Descriptive statistics suggest that the average deviation of actual compared with efficient allowance allocation for our sample amounts to 37 per cent.

Our result of a long position in the first ETS phase is in line with the findings of previous studies on EU ETS emission allocation (see Kettner et al., 2008 or Anger and Oberndorfer, 2008). In this context, it is important to note that verified EU ETS ex-ante emissions (e.g., from 2004 or earlier) were not published by the European Commission. Given this, verified emissions from 2005 are, on the one hand, the best available proxy variable for historical emissions as the main official allocation criterion. This lack of historical emission data makes it impossible to exactly identify why verified emissions in 2005 exceeded the respective number

[4] Table A. 2 in the appendix underpins that allowances allocated and emissions are strongly interrelated.

of allowances allocated. Although Ellerman and Buchner (2008) or Kettner et al. (2008) have considered abatement of emissions in the early EU ETS phase as both less important and realistic – and have therefore interpreted the phenomenon of verified emissions exceeding allocated allowances mainly as a sign of “over-allocation” of firms with EU allowances[5] – it cannot be excluded that absolute or relative allocation affected verified emissions of the respective companies. However, our sample with 91 per cent of companies being long in EU emission allowances due to grandfathering based on the German NAP, together with the existing literature, implies that little abatement at most has taken place inside of the ETS during its first phase. This is in opposition to the claim of, e.g., Böhringer et al. (2005), Kallbekken (2005), or Peterson (2006) that abatement of arount 10 per cent would have been economically efficient. Our econometric study starts at this point and addresses the determinants both of allowance allocation in general and of the deviation between actual and efficient allocation using firm-level data, and particularly focuses on potential lobbying influence on the allocation process.

As a potential determinant of allowance allocation within the EU ETS, the CREDITREFORM database reports the number of employees at the firm level. Here, we can especially make use of time series information from 2000 to 2004 on employment of the respective EU ETS firms. Given that EU ETS allowance allocation for the first trading phase was decided on in 2004 and the EU ETS came into force in 2005, 2004 employment levels could represent a determinant of allowance allocation, as worker lay-offs are traditionally a prominent argument of industries against environmental regulation (Kirchgässner and Schneider, 2003). However, also 2002 to 2000 employment levels are relevant to our analysis as they may serve as instrumental variables in the case of endogeneity problems.

The central explanatory variable of our political-economy analysis is the number of lobby employees of the representative industrial association in each subsector. Subsectoral classification is based on the Input-Output Table (IOT) 1993 (see Table A. 4 in the appendix for a mapping between all IOT sectors and respective

[5] According to this interpretation, participating firms had received allowances for a higher amount of CO_2 emissions than they actually emitted, implying a very loose emission cap of the EU ETS.

associations). This is the best available proxy for potential political support of sectoral interest groups for the government, as data on, e.g., financial budgets of interest groups is not available for Germany. One example of political support provided by interest groups is information transfer from interest groups to policy makers (see, e.g., Grossman and Helpman, 2001). Accordingly, political support is the stronger, the more representatives a lobby group employs (e.g., by processing and providing a larger amount of relevant information to the policy maker). Our lobby variable contains the number of lobby representatives of industrial associations based on an extensive telephone survey conducted in 2004, the year of the decision on EU ETS allowance allocation for the first trading phase.[6] For our sample, we can make use of lobby representative data of 14 EU ETS subsectors. On average, each of these sectors employed 108 representatives. However, the number of such employees at the sectoral level is very heterogeneous, ranging from 7 to 350. In order to differentiate between sectoral differences in allowance allocation that originate from lobbying activities and other sectoral factors (e.g., Buchner et al., 2006), we additionally generate three dummy variables (electricity, other energy, and manufacturing, with other sectors as reference category; see Appendix A.2) at the aggregate sectoral level in order to control for such industry effects. Controlling for industry effects at the less aggregated sub-sectoral level according to the Input-Output Table 1993 is not feasible as it would lead to perfect multicollinearity of sectoral dummy variables with the employed lobby variable.

Methodology

For our cross-sectional analysis, we depart from the ordinary least squares estimator (OLS) for equation:

$$y_i = \beta' x_i + \varepsilon_i , \tag{9}$$

[6] The survey has been conducted at the Centre for European Economic Research (ZEW) in Mannheim, Germany, during June and July, 2004. Contact details of associations were taken from a database of German industrial organizations (Hoppenstedt, 2003). For 42 manufacturing subsectors of the German economy (only 14 are relevant to our sample given the restriction of EU ETS to the four industry domains energy, production and processing of ferrous metals, minerals and pulp and paper) we covered the representative industrial associations, with a focus on members of the Federation of German Industries (BDI).

with y_i representing allowances allocated of firm *i*, x_i being the vector of explanatory variables of the respective firm as presented in the previous section, and β giving the vector of coefficients to be estimated. ε_i is a disturbance term that is independent and identically distributed across firms $i = 1,2,...,N$. Using OLS, the parameter vector is determined by:

$$\beta = [X'X]^{-1} X'y, \quad (10)$$

where matrix X consists of rows x_i', and y is the dependent variable's vector. While OLS serves as the starting point for our empirical analysis, it does not take into account the important issues of potential reverse causality.

Within the OLS approach, reverse causality problems may cause biased parameter estimation. As lined out in the preceding chapter, firm data on historical emissions is not available to date, which is why 2005 verified emissions (and possible variations of it) have to be used as explanatory variable(s) in the analysis of allowance allocation. Given the nature of the EU ETS allocation process that is officially based on historical emissions, neglecting emission data when analyzing allowance allocation is not an option due to the problem of causing biased parameter estimates because of omitted variables. Still, firm emissions in 2005 could have been influenced by the number of allocated emission allowances. Such an effect would cause reverse causality problems rendering the regression with allowances allocated (as dependent variable) and verified emissions (as explanatory variable) biased and inconsistent. Instrumental variable technique is the usual remedy to such econometric problem. Within a Two Stage Least Squares (2SLS) approach, in the first stage the fitted values x_i^* from a regression of the (possibly) endogenous variables x_i on the instruments z_i are produced, while in the second those fitted values x_i^* replace the endogenous regressors x_i in the regression of actual interest:

$$y_i = \gamma' x_i^* + \varepsilon_i. \quad (11)$$

Given this, the 2SLS estimator for the parameter vector γ can be written as:

$$\gamma = \left[X*'X*\right]^{-1} X*'y\,, \tag{12}$$

where matrix X^* consists of rows x_i^* (first stage regression fitted values for endogenous explanatory, i.e., emission variables, and exogenous explanatory variables, respectively). In the 2SLS approach, for instrumental variables to be valid two prerequisites have to hold: correlation between z_i and the endogenous variable to be instrumented x_i should be non-negligible, while z_i and the second-stage error term (ε_i from equation (11)) have to be uncorrelated. Firm employment levels and squared terms between 2000 and 2002 are chosen as instrumental variables in this analysis: they can be interpreted as indicators of firm size, a natural determinant of the amount of CO_2 emissions of energy-intensive companies. Moreover, being predetermined, there is no reason to expect correlation with the second stage regression error term. This should particularly hold as the regression analysis controls for an effect of 2004 (the year of the NAP decision) employment on the allocation outcome. Clearly, the validity of firm employment variables from 2000 to 2002 as instrumental variables could be challenged if allowance allocation in the year 2004 was determined by employment levels of earlier periods. However, as current – instead of past – employment reflects the threat of possible worker lay-offs due to regulation (Kirchgässner and Schneider, 2003), lagged 2000 to 2002 employment figures should not have affected the allocation outcome in 2004. Consequently, firm employment variables from 2000 to 2002 appear to be appropriate instruments for the verified emissions and respective transformations.

Estimation Results

In the following, we empirically assess the determinants of EU ETS allowance allocation at the German firm level. To this aim, we pursue a twofold goal: (i) to address potential inefficiencies of allowance allocation – referring to theoretical Proposition 2 of this chapter – and (ii) to analyze factors determining the distribution of allocated allowances within the EU ETS – referring to theoretical Proposition 3 presented in section 2.1.2.

Efficiency Implications of Lobbying

First, Proposition 2 suggested that the government's consideration of interest groups from ETS sectors can lead to inefficiently high levels of allowance allocation. We aim at testing this proposition by assessing the determinants of the variable measuring the deviation from efficient allocation – derived as the actual allowance allocation less the efficient one. As mentioned above, however, it cannot be excluded that actual allocation – and therefore also the deviation from efficient allocation – affected verified emissions of the respective companies. In this case, estimation by OLS would yield biased and inconsistent results due to reverse causality problems. This can be circumvented by applying an instrumental variable approach such as 2SLS. In the 2SLS estimation, the verified emissions variable and its interaction terms and nonlinearities are instrumented in a first stage regression by lags (2000 to 2002) and the associated squared terms of the employment variable in addition to the explanatory variables of the 2SLS second stage equation. The corresponding estimation results – both for OLS and 2SLS – are presented in Table 1.

The empirical set-up provides a good fit to our data set here, as shown by a high R-squared for both econometric techniques used. Accordingly, also the null hypothesis of joint insignificance of all explanatory variables can be rejected at the 1%-level for both techniques (F-Test). According to the F-Test, there is also no indication for a misspecification of the 2SLS approach. First stage regressions of the verified emissions, squared verified emissions and the interaction terms between verified emissions and the lobby variables on the instruments (2000 to 2002 levels and squared terms of employment at the firm level) are well specified, as the null hypothesis of joint insignificance of all explanatory variables can be rejected at any conventional level (see Table A. 3 in the appendix).

For the OLS regression, Table 1 shows a positive sign of the estimated coefficient of the verified emissions variable. In contrast, IV regression does not indicate that verified emissions actually impacted on the deviation from efficient allocation for the respective firm. This underpins the reasoning that verified emissions are endogenous in this setting: If, compared to its efficient level, a generous allowance allocation would have caused additional CO_2 emissions of the respective firm, OLS (in contrast to 2SLS) estimation should yield an upward biased verified emissions coefficient. This corresponds to our results, with a positive and significant OLS verified emissions coefficient and an insignificant (and even negative) 2SLS verified emissions coefficient.

Table 1 Estimation Results: Deviation from Efficient Allocation

Dependent variable: Deviation from efficient allocation	**OLS**	*2SLS*
Verified Emissions	2.30***	-0.42
	(0.00)	(0.75)
Squared Verified Emissions	-2.20**	-4.36***
	(0.01)	(0.00)
Employment 2004	-0.17	-0.03
	(0.25)	(0.79)
Lobby	-0.07	-0.06
	(0.16)	(0.33)
Lobby x Verified Emissions	0.54	5.50***
	(0.58)	(0.00)
Lobby x Employment 2004	0.16	0.03
	(0.32)	(0.82)
No. Obs.	175	131
R-sq.	0.83	0.89
F-Test (P-Val.)	0.00***	0.00***

Note: Deviation from efficient allocation defined as allowances allocated minus efficient allocation (see above). Standardized coefficients (regression coefficients obtained by standardizing all variables to have a mean of 0 and a standard deviation of 1) are reported. P-values in brackets (based on White robust std. errors). Estimations include sectoral dummy variables (estimated coefficients not reported). *, **, and *** indicate significance at the 10%-, 5%-, and 1%-level, respectively.

For both estimation techniques, the squared term of the emission variable (included in order to control for nonlinearities in the relationship between emissions and the allocation process) enters highly significantly into the estimated regression equation. Its negative sign suggests that – for a given effect of absolute emission levels on allowance allocation – large emitters received relatively less allowances compared to small emitters as measured by the deviation of the actual from an efficient level of allowance allocation.

Let us now turn to the role of interest groups in EU ETS allowance allocation. The estimated coefficient for the variable indicating the number of lobby employees does not significantly differ from zero at any conventional level, a result which at first sight does not confirm our theoretical prediction of Proposition 2 in the previous section. This holds for both estimation techniques applied. The estimated coefficient for the lobby variable does neither alter substantially when the instrumental variable technique to verified emissions-related variables is applied. However, we find an interesting result concerning the coefficient of the interaction term between the lobby and emission variable: while standards OLS estimation does not yield significant parameter estimates, the coefficient of the interaction term is highly significant and positive under 2SLS. Note that the latter represents the adequate technique for our setting, as it eliminates estimation biases due to reverse causality of the emission variable. This central empirical result suggests that the combination of high emissions at the firm level and powerful lobbying activities in the respective sector induced – ceteris paribus – an upward deviation of actual compared to an efficient level of allocated allowances for German firms in the EU ETS. Consequently, the analysis corroborates our theoretical Proposition 2, which suggested a positive impact of lobbying power on the deviation of allowance allocation from an efficient level. However, the estimations show that lobbying was only beneficial for large emitters. This empirical finding implies that the effect of lobbying on the deviation of allowances allocated to an efficient scenario is conditional on firm characteristics. The level of employment of a firm did, according to our dataset, not have an impact on the deviation of allowances allocated from an efficient setting. Moreover, the effect of lobbying power was not increased by the argument of high employment of the respective firm, as measured by the corresponding interaction term that does not significantly differ from zero in both empirical settings. Both estimations include dummy variables indicating the sectoral affiliation at an aggregate level (electricity, energy, and manufacturing sector) in order to control for general sectoral effects within the allocation process. These central results also hold when these sectoral indicator variables or, alternatively, insignificant explanatory variables are eliminated from the estimation (all detailed estimations are available on request from the authors).

Clearly, these firm-level results do not directly provide evidence for an economy-wide inefficiency of emission regulation in terms of a too high allowance allocation for ETS sectors, as the observed deviations from the optimal allocation factor could potentially cancel out across firms. However, as our descriptive statistics show that as much as 91 per cent of German companies featured a long position in EU Emission Allowances, and that the average position of our sample firms was long by about 30 per cent, such an aggregation effect can be excluded. As a consequence, the 2SLS estimation results support our theoretical proposition of an inefficient allowance allocation process due to the presence of sectoral interest groups.

Result 1: Sectoral lobbying induces a deviation of the actual allocation of emission allowances from its economically efficient level, if the corresponding firms are highly exposed to emission regulation.

Distributional Implications of Lobbying

Second, theoretical proposition 3 suggested that in an emission trading scheme with several sub-sectors, those industries featuring higher lobbying power receive a higher absolute level of allowance allocation. In the following, we test this distributional hypothesis using our German firm-level dataset. In the first phase of the EU ETS, absolute allowance allocation was based on historical emissions, which we can proxy by using the verified emissions variable available in the community transaction log. All variables employed in the analysis presented above can also be considered in the analysis of allocation distribution. As in the case of the deviation of the actual from an efficient level of allowances allocated, however, it cannot be excluded that absolute allocation affected verified emissions of the respective companies. Therefore, also for the following estimations, employing 2SLS and using the same instrumental variables as in the previous regressions should be the most adequate empirical approach (therefore, the first stage regressions are also identical to those ones presented in Table A. 3 in the appendix, and well specified).

The corresponding estimation results – both OLS and 2SLS – are shown in Table 2. As expected, the empirical set-up provides a very good fit (an even better fit compared to the results presented in Table 1) to our data set here, as shown by a very high R-squared for both econometric techniques used. Particularly verified emissions of the firms analyzed here have very strong explanatory power for the allowances allocated manifesting in a high statistical significance of the respective coefficients (at the 1%-level for each estimation technique). The null hypothesis of joint insignificance of all explanatory variables can be rejected at the 1%-level for both techniques (F-Test), giving no indication for misspecification. Note that the estimation results presented in Table 2 partly resemble their counterparts shown in Table 1. This may underpin the robustness of those results, but is also due to the fact that the dependent variable construction for the deviation from efficient allocation was also based on allowances allocated.

Table 2 shows a positive sign of the estimated coefficient of the verified emissions variable, which corresponds to the nature of the EU ETS allocation process suggesting that emission levels have a positive impact on the level of allowance allocation. For both estimation techniques, also the squared term of the emission variable (included in order to control for nonlinearities in the relationship between emissions and the allocation process) enters highly significantly into the estimated regression equation. Its negative sign suggests a concave relationship between verified emissions and allowances allocated. This result substantiates our theoretical finding of condition (8), which stated that quadratic emissions levels play a role for the implemented allowance allocation.

Table 2 Estimation Results: Distribution of Allowances

Dependent variable: Allowances allocated	**OLS**	*2SLS*
Verified Emissions	1.13***	0.91***
	(0.00)	(0.00)
Squared Verified Emissions	-0.19***	-0.32***
	(0.01)	(0.00)
Employment 2004	-0.01	-0.00
	(0.25)	(0.79)
Lobby	-0.01	-0.00
	(0.16)	(0.33)
Lobby x Verified Emissions	0.05	0.40***
	(0.58)	(0.00)
Lobby x Employment 2004	0.01	0.00
	(0.32)	(0.82)
No. Obs.	175	131
R-sq.	0.99	0.99
F-Test (P-Val.)	0.00***	0.00***

Note: Standardized coefficients (regression coefficients obtained by standardizing all variables to have a mean of 0 and a standard deviation of 1) are reported. P-values in brackets (based on White robust std. errors). Estimations include sectoral dummy variables (estimated coefficients not reported). *, **, and *** indicate significance at the 10%-, 5%-, and 1%-level, respectively.

As in the regression analysis assessing the efficiency of allocation, the estimated coefficient for the variable indicating the number of lobby employees does not significantly differ from zero at any conventional level, while the coefficient of the interaction term between lobby representatives and verified emissions is highly significant and positive under 2SLS. Also in this setting, 2SLS represents the adequate technique, as it eliminates estimation biases due to reverse causality of the emission variable.[7] This central empirical result suggests that the

[7] The magnitude of the (highly significant) estimated coefficient of the emission variable for 2SLS is smaller than for OLS estimation, which may be a sign of actual reverse causality of the emission variable, as one would expect the effect of allowances allocated on verified emissions to be positive. For this case, i.e., that "over-allocation" led to higher actual emissions and more stringent

combination of high emissions at the firm level and powerful lobbying activities in the respective sector induced higher levels of allocated allowances for German firms in the EU ETS. Consequently, the empirical analysis corroborates our theoretical Proposition 3, which predicted a positive impact of sub-sectoral lobbying power and simultaneously high emission levels on the allocation of allowances. In particular, it underlines that the role of lobbying for the distribution of allocated allowances in the EU ETS is conditional on firm characteristics.

Given the insignificant coefficients of the lobby variable itself, the employment variable and the employment-lobbying interaction term, together with the theoretical model the 2SLS estimation results indicate that lobbying may influence the allocation process only in combination with specific economic characteristics of the respective industries: a high exposure to environmental regulation in terms of a high emission level. In contrast, there is no indication that the level of firm employment matters for allowance allocation. Put differently, we find that in the EU ETS industrial arguments against environmental policy which were directly linked to regulatory exposure played a more critical role than more indirect policy issues. The estimations include sectoral dummy variables (see above) but are robust to their or the elimination of insignificant explanatory variables from the estimation.

Result 2: Allowance allocation in the EU Emission Trading Scheme is distributed in favour of sectors represented by powerful lobby groups, if the corresponding firms are highly exposed to emission regulation.

2.1.4. Conclusions

This chapter assessed the political-economy aspects of allowance allocation in the EU Emission Trading Scheme (EU ETS) both on theoretical and empirical grounds. We developed a simple analytical framework of the role of interest groups for the allocation of emission allowances in a cap and trade system. The

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allowance allocation led to more abatement, OLS would over-estimate the impact of verified emissions on allowances allocated. Such a bias can be eliminated using the 2SLS technique.

model is structured as a *common-agency* problem, in which several principals (sectoral interest groups) aim to induce an action from a single agent (the government). In the stylized model, lobbying may influence political decisions, as the government does not only value social welfare but also political contributions by interest groups. As a consequence, the government's valuation of political contributions by interest groups from sectors covered by the emission trading scheme leads to inefficiently high levels of allowance allocation, thereby shifting the regulatory burden from those sectors covered by the trading scheme to the remaining industries of the economy. In order to fulfill the national emission target, the latter have to be regulated by an inefficiently high emission tax. Besides this efficiency result, we find that the distribution of permits within the emission trading scheme is biased in favor of those sub-sectors that feature more powerful lobby groups and higher emission levels.

An empirical analysis of the first trading phase of the EU ETS corroborates our two central theoretical findings predicting a strong role of interest groups for an inefficient emission regulation and a positive impact of sub-sectoral lobbying power on allowance allocation. The empirical analysis suggests that the presence of interest groups has induced a deviation of the actual allocation of EU ETS emission allowances from its economically efficient level. However, the estimations show that lobbying was only beneficial in combination with a high level of CO_2 emissions. This implies that large carbon emitters that were heavily exposed to emission regulation and simultaneously represented by powerful interest groups received inefficiently high levels of emission allowances. In contrast, stand-alone threats of potential worker layoffs did not exert a significant influence on the EU ETS allocation process. Furthermore, in accordance with our theoretical findings the estimation results suggest that the lobbying effect on the distribution of permits within the EU ETS is conditional on emissions, i.e., specific firm characteristics. These empirical results emphasize that the combination of lobbying for permits and high emitting activity affect both the distribution of allowances and the efficiency of regulation.

Suggesting that industrial lobbying has played a crucial role for emission allocation at the German level, our results corroborate the existing critique on the allocation process of the EU ETS. The findings of both our theoretical and empirical analysis thus provide arguments in favor of the use of auctioning instead of a grandfathered allowance allocation. The claim for an increased use of auctioning in emission trading systems has, up to now, been mainly based on theoretical arguments concerning the reduction of tax distortions, the enhanced provision of innovations, and the elimination of potential lobbying influence (Cramton and Kerr, 2002). Despite the more stringent allowance allocation in the second trading phase of the EU ETS and the increasing application of auctioning, our empirical results thus provide new support for the use of auctioning in emission trading. To complement our primary insights into the determinants of EU emission allowance allocation, empirical assessments for additional EU Member States as well as the second EU ETS trading phase constitute interesting directions for future research.

2.2. Firm Performance and Employment in the EU Emission Trading Scheme: An Empirical Assessment for Germany[8]

2.2.1. Introduction

In 2005, the European Union Greenhouse Gas Emission Trading Scheme (EU ETS) was launched (EU, 2003). The scheme represents a cornerstone of the efforts by EU Member States to fulfil the emission reduction targets under the Kyoto Protocol. This agreement requires European countries to reduce their greenhouse gas emissions on average by eight per cent until 2012 compared to 1990 emissions levels (UNFCCC, 1997). The EU ETS covers European producers in four sectors, namely energy (e.g., electric power, oil refinement), production and processing of ferrous metals, minerals (e.g., cement, glass), as well as pulp and paper. The ETS currently covers almost half (46 per cent) of total CO_2 emissions of EU countries. While in the scheme's first phase (2005 to 2007) almost all emission allowances are grandfathered by means of National Allocation Plans (NAPs) of each Member State and only up to five per cent may be auctioned, in the second phase (2008 to 2012) the auctioning limit rises to 10 per cent. Furthermore, the amending directive linking the EU ETS with the Kyoto Protocol's project-based mechanisms enables EU companies to generate emission reductions by means of the Clean Development Mechanism (CDM) or Joint Implementation (JI) (EU, 2004).

Since its initiation, the EU ETS has been accompanied by discussions on potential losses in competitiveness in international markets of companies that are covered by the EU ETS legislation.[9] Against this background, this chapter presents a first

[8] This chapter is based on the research paper "Firm Performance and Employment in the EU Emissions Trading Scheme: An Empirical Assessment for Germany", co-authored by Niels Anger and Ulrich Oberndorfer (Correspondence is to Ulrich Oberndorfer). The paper has appeared in Energy Policy 36 (2008), 12-22.

[9] For a recent overview on model-based assessments of costs and competitiveness effects of the EU ETS see Oberndorfer and Rennings (2007).

empirical assessment of the effects of the EU ETS on firm performance, i.e., competitiveness, and employment. Following Balassa (1962), we define competitiveness as a firm's ability "to sell on foreign and domestic markets" and approximate this ability by firms' market revenues. We rely both on real-world data on allocated allowances and verified emissions for the first trading period from the EU Community Independent Transaction Log (EU, 2007) and on economic firm-level data from two comprehensive databases.

Previous quantitative studies have assessed the efficiency aspects and competitiveness implications of the EU ETS predominantly in numerical modeling frameworks. Böhringer et al. (2005) show that the exclusive coverage of energy-intensive installations by EU ETS implies that – in the absence of the potential use of CDM and JI – the remaining industries have to be regulated by complementary abatement policies in order to meet the national Kyoto targets. Such a hybrid emission regulation can cause large inefficiencies within EU economies, but may also worsen the prospects of linking the EU ETS to emerging emission trading schemes beyond Europe (see Anger, 2008). Unlike employment aspects of the EU ETS, competitiveness implications of the current European trading scheme have been analyzed in numerical model frameworks (Kemfert et al., 2005; Klepper and Peterson, 2004; Peterson 2006). The sectoral competitiveness implications of allowance allocation under the EU ETS have been assessed both for the European electricity industry (Neuhoff et al., 2006) and the cement sector (Demailly and Quirion, 2006). Enlarging the purely European perspective, Alexeeva-Talebi and Anger (2007) assess both the economy-wide and sectoral competitiveness effects of linking the EU ETS internationally to emerging trading systems outside Europe (such as Japan, Canada or Australia) within an applied general equilibrium model framework.

The previous empirical literature on emission regulation under the EU ETS is rather scant. Analyzing the verified emissions of the participating installations as well as the respective allowances allocated, Ellerman and Buchner (2008) conclude that "over-allocation occurred and that its magnitude may have been as much as 100 million EU allowances". Kettner et al. (2008) present similar findings, suggesting that in the first EU ETS trading year the scheme was in a long position regarding emission allowances. Moreover, to date there is no empirical contribution assessing the competitiveness or employment impacts of emission allocation under the EU ETS. This chapter aims at starting to fill this gap. In this respect, the contribution of this analysis is twofold: Relying on installation-level allocation data from the EU Community Transaction Log in 2005, we (i) descriptively assess the relative allowance allocation under the EU ETS at the national level and (ii) econometrically test for competitiveness and employment impacts of the EU ETS for a large sample of German companies.

This chapter is structured as follows: Section 2.2.2. summarizes the empirical literature. Section 2.2.3. discusses the relative allowance allocation in Europe as well as the data underlying the empirical analysis for Germany. Section 2.2.4. presents the econometric assessment and section 2.2.5. concludes.

2.2.2. Literature Review

The necessity of environmental regulation is mainly based on the reasoning that there are social costs of negative externalities such as pollution. However, strict environmental regulation is often accused of harming the competitiveness of the affected sector or firm. Such adverse economic effects (and especially effects on competitiveness) of environmental regulation are challenged by the so-called Porter hypothesis, suggesting that environmental regulation provides incentives for companies to innovate and that these innovations can stimulate economic growth and competitiveness of the regulated country (Porter and van der Linde, 1995).

In the context of competitiveness and employment, an important characteristic of emission trading schemes is the choice of the underlying allocation method. There are several studies dealing with this issue: Demailly and Quirion (2008) quantify the impact of the EU ETS on production and profitability as two dimensions of competitiveness for the iron and steel industry. They find that competitiveness losses for this sector are small but are significantly determined by pass-through rates and the updating of allocation rules. While emission-based updating should be avoided as it creates perverse investment incentives, output-based updating has ambiguous competitiveness effects – softening production losses, but reducing the likely gains in earnings before interests, taxes, debt and amortization. Böhringer and Lange (2005a) investigate the trade-off between compensation and economic efficiency for output- and emission-based allocation rules in an international emission trading scheme. They find that the output-based rule not only induces substantially lower efficiency losses than the emission-based rule, but also performs better in ameliorating adverse production and employment effects for energy-intensive industries. Fischer and Fox (2007) present a welfare analysis of alternative emission allocation rules within a domestic U.S. emission trading scheme, focusing on sectoral and international leakage as generated by restricted sectoral coverage of domestic ETS and unilateral action. They find that, given domestic and international leakage, output-based allocation of emission permits to the covered sectors is preferable to auctioned permits in welfare terms, even when allowing for pre-existing tax distortions. Moreover, grandfathered permits generate the highest welfare costs of emission regulation.

Our empirical literature review focuses on competitiveness, as the empirical literature on employment effects of environmental regulation is rather scant. One exception is Golombek and Raknerud (1997) who empirically assess the employment effects of imposing environmental standards on polluting firms. Using Norwegian data they find that for two out of three manufacturing sectors, firms under strict environmental regulations had a higher tendency to increase employment and a lower tendency to exit than firms under weak or no environmental regulation.

Empirical analysis of the effects of environmental regulation on competitiveness, or, more general, economic performance of firms or sectors is rather rare, too, as truly exogenous measures are often barely accessible. Pickman (1998), Brunnermeier and Cohen (2003) as well as Jaffe and Palmer (1997) use U.S. Pollution and Abatement Costs and Expenditures (PACE) as a proxy of stringency of environmental regulation in order to test for innovation effects of U.S. industries. However, such costs may depend on other factors such as the response to regulation, as well as the right measurement and exact self-report of firms and industries. Therefore, it is unclear whether compliance costs under- or overstate true regulation costs (Brunnermeier and Cohen, 2003). Pickman (1998) as well as Brunnermeier and Cohen (2003) find evidence that those costs positively affect innovation, while the results of Jaffe and Palmer (1997) do not confirm such causal relationship. What is more, it is controversial if a positive effect of environmental regulation on innovation (or even environmental innovation) would imply a positive competitiveness record of environmental regulation, as, e.g., opportunity costs (e.g., other investment or conventional innovations that have not been realized due to the burden of regulation costs) are neglected in such a setting.

Such problems do not arise in event studies on environmental regulation. Such studies measure the impact of environmental regulation on stock returns of firms (possibly) affected. They often only compute short term financial market reactions, however. Furthermore, they hinge on the assumptions of efficient financial markets and of no anticipation of regulation by the market actors, which may often be very crucial for the interpretation of the results computed. Butler and McNertney (1991) consider the effect of elections, namely the 1982 state-wide gubernatorial elections in six U.S. states. These states were identified as those where the election results were uncertain and expected to affect environmental regulation for energy utilities. The study shows that in those states in which the victory of a Democratic governor was most unpredictable significantly negative cumulative abnormal returns arise. Blacconiere and Northcut (1997) consider the impact of the U.S. Superfund Amendments and Reauthorization Act (SARA) of 1986 on stock returns for corporations from the chemical industry, finding significant negative cumulative abnormal returns only for 17 out of 26 SARA related events analyzed. Two more recent studies consider the effect of the U.S. Clean Air Act Amendments of 1990 on stock returns for energy utilities (Diltz, 2002, Kahn and Knittel, 2003). Both studies can not show sharp financial market reactions. Oberndorfer and Ziegler (2006) find that the German phasing out of nuclear energy (similarly to Butler and McNertney, 1991, measured by the victory of the acting government with participation of the Green party in the 2002 German Federal Elections) had at least no general negative short- and mid-horizon effect on the economic performance of energy corporations. As far as the EU ETS is concerned, there are not yet empirical contributions available that measure competitiveness impacts of the introduction of and allocation inside of the scheme.

All in all, most of the existing studies find only weak evidence of an effect of environmental regulation on firm performance. Furthermore, all groups of approaches tackling the question about performance – competitiveness – impacts of environmental regulation have their idiosyncratic flaws: While innovations do not represent an ideal competitiveness indicator and the use of compliance costs as a proxy for regulation is not uncontroversial, most event studies only focus on short term financial market reactions given environmental regulation. For the EU ETS, no empirical contribution on competitiveness impacts is available yet. Preliminary and descriptive evidence, however, suggests that the scheme is characterized by a relatively generous emission cap compared to verified emissions.

2.2.3. Data and Variables

In this section we present the data basis underlying to the emission allocation within the EU Emission Trading Scheme. This is done by firstly giving an overview over (relative) allocation at the national level for all EU ETS countries. In a second step, we present the data basis used for our empirical policy assessment of employment and competitiveness effects associated with EU ETS relative allowance allocation in Germany.

EU ETS Data

The 2005 allocation data was extracted from the Community Independent Transaction Log (CITL; EU, 2007). The allocation factor measures the allocation of EU emission allowances relative to the actual emissions of the respective entity and is calculated as the quotient of allowances allocated to the verified emissions. The allocation factor thus shows the relationship between the amount of allocated allowances and actual emissions, i.e., an allocation factor larger than 1 suggests that an entity has received allowances that exceed its emissions while an allocation factor smaller than 1 suggests that the respective entity either has to buy additional emission allowances or abate some of its emissions in order to comply with EU ETS regulation. In this context, one problem may be that verified emissions do not stem from a pre-EU ETS period (this emission data is actually not available) but from 2005 and are thus of ex-post nature. Therefore, relative allocation can not be distinguished from actual early abatement in 2005 and also the allocation factor has an ex-post character.[10] First evidence, however, suggests that abatement in 2005 remained relatively low, so that the allocation factor should be at least a very good indicator of relative allocation (Ellerman and Buchner, 2008).

Figure 1 shows the allocation factor, aggregated at the national level and based on disaggregated installation level data from the CITL, for all EU ETS countries. Our aggregated data relies on 10,276 installations, covering the entire set of identifiable EU ETS installations. It indicates that companies in some countries – e.g., Ireland and the UK – have received fewer allowances than their respective emissions while companies from other countries have received a large relative amount of emission allowances given their actual emissions. Noteworthy in this respect is Lithuania, with its companies having received allowances for more that twice of their actual emissions. For the EU ETS level, the data extracted from the CITL suggests that in 2005, the scheme as a whole was in a long position. Furthermore, it already indicates that the relative allowance allocation enormously differs across single entities. This is in line with the findings of Kettner et al. (2008).

[10] Moreover, note that the allocation factor is dependent on factors such as stochastic variations in weather, production, energy prices, or other variables affecting emission.

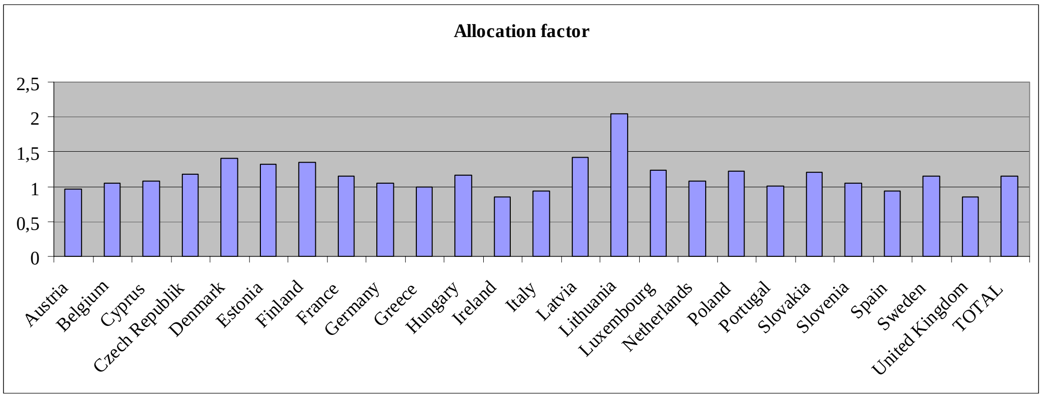

Figure 1 Allocation Factors at an Aggregate National Level for EU ETS Countries (Source: Own Calculations)

More specifically, Kettner et al. (2008) consistently with our calculations identified Lithuania as the country exhibiting the biggest "net long" position and Ireland and the UK as countries exhibiting the biggest "net short" position within the scheme. Additionally to our calculations, however, they provide information on long and short positions at the sector level which is not in the focus of our analysis.

German Sample

In the framework of an empirical analysis for Germany, we want to assess the impact of relative allocation of EU emission allowances on competitiveness and employment at the firm level. The econometric analysis can only be conducted within a case study for Germany, as economic variables that could indicate the development of competitiveness and employment at the firm level up to 2005 were not available to us for all EU countries. Still, the econometric analysis may offer important insights into the economic effects of the EU ETS in Europe as a whole, as Germany is the most important country within the EU ETS, its companies representing about 24 per cent of all allowances allocated. To our knowledge, our approach represents the first ex-post analysis of the economic impacts of the EU ETS.

For the purpose of this empirical investigation, EU ETS allocation data stemming from the CITL (EU, 2007) (i.e., the allocation factor, see above) was aggregated at the firm level for Germany. The relative emission allocation data subsequently was matched with economic data from the CREDITREFORM database. Sectoral (indicator) variables were generated according to the 4-digit NACE industry codes that are contained in the AMADEUS database. Our sector classification includes the business, electricity, energy, mining, coke & petroleum, pulp & paper, and (other) manufacturing sectors. For more detailed information on the economic, sectoral and emission data employed in this analysis please refer to the Appendix.

All in all, given our economic data, 419 German firms covered by the EU ETS could be analyzed in the empirical framework. Table 3 gives first information on the 2005 data from the CITL and the CREDITREFORM database. It shows that on average, the companies included in the empirical analysis have been, in comparison with all German EU ETS participating firms, relatively highly allocated with EU emission allowances. While for Germany as a whole, the allocation factor is 1.04, for the sample analyzed it is 1.24. Furthermore, the economic data indicates that in 2005, the decisive year of our analysis, the firms included have on average, under circumstances of shrinking revenues, reduced their number of employees. More than a quarter of our sample firms stem from the manufacturing sector, mining and coke & petroleum firms, in contrast, are very infrequent here. 153 firms could not be classified in our sectoral classification (for an overview over the sectoral distributions, see Table A. 5 in the Appendix).

Table 3 Descriptive Statistics of German Firm Data

	No. Obs.	*Mean*	*Std. Dev.*	*Min*	Max
Allocation Factor	419	1.24	0.57	0.26	5.95
Allowances Allocated	419	603961.5	4795754	272	9.02e+07
Verified Emissions	419	579399	4862883	50	9.12e+07
Revenues 2005-2004	419	-139.43	3982.08	-79678.02	8361.04
Revenues 2004-2003	419	77.01	507.40	-320.02	8539.71
Revenues 2003-2002	419	-18.92	1917.70	-21191.99	18451.61
Revenues 2005	419	972.32	4423.90	0.16	56172.84
Revenues 2004	419	1111.75	7340.71	0.16	135850.90
Revenues 2003	419	1034.74	7080.48	0.16	131569.00
Employees 2005-2004	419	-413.08	5367.39	-73336	22660
Employees 2004-2003	419	424.90	5328.04	-3508	72712
Employees 2003-2002	419	-80.21	705.73	-6899	3850
Employees 2005	419	2705.22	20010.84	1	384723
Employees 2004	419	3118.29	20606.48	1	362063
Employees 2003	419	2693.39	19104.49	1	365571

Note: Revenue Data is given in Mio. Euro and is measured in prices of 2000 (GDP market price deflator). Revenues give the value of annual sales of goods and services – including other types of revenue such as dividends, interest, and rent – of the respective company.

2.2.4. Econometric Analysis for Germany

Estimation Approach

An econometric analysis is the only means to empirically measure the impact of relative allocation of EU emission allowances on competitiveness and employment. In the following we employ a regression analysis in order to test whether the relative allocation (as measured by the allocation factor) had an impact on competitiveness as measured by firm revenues – here: representing the "ability to sell" as one concept of competitiveness[11] – and employment of the

[11] As our empirical assessment focuses on the EU ETS, we refer to within-EU competitiveness among EU firms here (as opposed to international competitiveness vis-à-vis non-EU regions).

German firm sample. The related correlations are shown in Table A. 6 in the Appendix. As dependent variables we use the firm revenue change in 2005, i.e., revenue 2005 minus revenue 2004, as an indicator of their ability to sell, and firm employment change in 2005, i.e., number of employees 2005 minus number of employees 2004. As it is common for an analysis with cross-sectional firm data and a continuous dependent variable (in both cases), we use ordinary least squares (OLS) in a first step in order to compute our regression results. Still, as lined out in the previous sections, the explanatory variable of our special interest in this analysis, the allocation factor, may be endogenous in such setting. This is due to the fact that its calculation is based on (verified) emissions from 2005 given that historic emission data is not publicly available.

However, if revenue and/or employment development in 2005 had an impact on the respective emissions, reverse causality would render our estimation results from OLS biased and inconsistent. As the most common technical solution in such setting, additionally to OLS, we make use of instrumental variable technique employing the so-called Two Stage Least Squares Estimator (2SLS). Doing this, in the regression equation of our interest (second stage), the possibly endogenous allocation factor is replaced by its fitted values from its (first stage) regression on exogenous variables (so-called instruments). As instruments for the allocation factor, firm data on revenues and employment in differences and levels are available besides sectoral variables that partly more strongly correlate with the allowance factor than the economic variables do. Furthermore, OLS results have been controlled for possibly outlier-driven results using so-called Iteratively Reweighted Least Squares (IRLS), the most common “robust” regression method. However, analogously to the OLS results, IRLS regressions may suffer from reverse causality problems. Given this fact (and the fact that our central results on relative allocation are consistent for all techniques applied), IRLS results are only displayed in the Appendix, and interpretation focuses on OLS and 2SLS.

Estimation Results

The central results of the regression analysis are shown in Table 4 (Table A. 7 and Table A. 8 in the Appendix give the more detailed results). In the regression analysis (1) using revenue changes between 2005 and 2004 as a dependent variable, we include, besides the sectoral indicator variables and a constant term, the allocation factor as the explanatory variable of our major interest as well as revenue differences 2004-2003, revenue differences 2003-2002, revenues 2003, the number of employees 2003, and the differences of the number of employees 2004-2003 as explanatory (control) variables. Using *lagged* levels and differences of revenues and employment as explanatory variables, we circumvent possible reverse causality or simultaneity (endogeneity) problems that can arise if the dependent variable has an influence on these explanatory variables.[12] Regression (3) gives the respective 2SLS results, (5) the IRLS results. From (2), (4), and (6), insignificant explanatory variables (besides the allocation factor) have been eliminated. For OLS and 2SLS, such elimination of insignificant explanatory variables is supported by an F-Test. All in all, our results show a good fit of the econometric model, with an R-squared of 84 per cent. According to the results of an F-Test, the null hypothesis of joint insignificance of all explanatory variables can be rejected at the 1%-level for any equation. The results, i.e., the parameter estimates of significant variables as well as their significance levels, are relatively robust to the choice of estimation technique as well as to the elimination of insignificant explanatory variables.

[12] In contrast to the allocation factor which we instrument in the 2SLS approach, these explanatory variables are incorporated in lagged form instead of being instrumented. Thereby we assume actual lagged relationships between the explanatory and independent variables.

Table 4 Selected Regression Results for German Firm Sample

Dep. Var.	***Revenues 2005-2004 (Mio. Euro)***		No. Employees 2005-2004	
Regression Number / Estimation Technique	*(1) OLS*	*(3) 2SLS*	*(7) OLS*	*(9) 2SLS*
Allocation Factor	122.14	50538.58	30.23	-44067.80
	(110.72)	(42836.84)	(119.04)	(48347.34)
No. Obs.	419	419	419	419
R-squared	0.84	0.84	0.85	0.85
F-Test (p-Value)	0.00	0.00	0.00	0.00

Note: (White) robust std. errors in brackets. Results from regressions including the full set of control variables. Detailed results including parameter estimates of the control variable set (cp. regression numbers), as well as results of regression equations from which insignificant control variables have been eliminated and the IRLS estimations is given in the Appendix.

The main insight of this regression is that we do not find empirical evidence for a significant impact of the relative allocation of EU emission allowances on firm revenue development in 2005. From a theoretical emission-market perspective, a higher relative (grandfathered) allowance allocation induces lower compliance costs of emission regulation (see, e.g., Böhringer et al., 2005). Thus, relative allowance allocation and the subsequent trading of emission permits affect the cash flow of the regulated firms. Clearly, the impacts of environmental regulation on firm revenues, production and employment are more complex and depend on the allocation rule (Demailly and Quirion, 2008). Our estimation results show a positive coefficient of the allocation factor both in the OLS and 2SLS regressions which, given large standard errors, does not significantly differ from 0 in all equations presented in Table A. 7 in the appendix.

Our results thus suggest that companies that received a relatively high amount of allowances within the allocation process could not, consequently, increase their revenues compared to other German companies within the emission trading scheme. Besides the sectoral indicator variables that show a highly significant impact on revenue development, which can for example be explained by differences in sectoral demand, most other control variables do not show significance at any conventional level. An exception to this is the coefficient of the number of employees in 2003 that enters with a negative sign in the equation (with an estimated coefficient of about -0.20), suggesting that firms with a larger working force were less successful in increasing their revenues in 2005. IRLS gives partly different results, but, as indicated above, does not show any significance for the estimated coefficient of the allocation factor, neither.

In the regression analysis (7) using the changes of the number of employees between 2005 and 2004 as a dependent variable, we include, besides the sectoral indicator variables and a constant term, the allocation factor as the explanatory variable of our major interest as well as revenues 2004-2003, revenues 2003, the number of employees 2003, the number of employees 2004-2003, and the number of employees 2003-2002 as explanatory (control) variables. As in regression no. (1) to (6), the use of *lagged* levels and differences of revenues and employment as explanatory variables is due to the potential problem of endogeneity as well as of assumed lagged relationships (see footnote 4). Here as well, the results are robust to the elimination of insignificant explanatory variables and show a good fit of the econometric model, with an R-squared even slightly higher than in regression no. (1) to (4) (up to 85 per cent). According to the results of an F-Test, the null hypothesis of joint insignificance of all explanatory variables can be rejected at the 1%-level for all approaches used. Regression (9) gives the respective 2SLS results, (11) the IRLS results. From (8), (10), and (12), insignificant explanatory variables (besides the allocation factor) have been eliminated (exclusion is supported by an F-Test for the 2SLS and the IRLS case).

Analogously to the revenue analysis, we do not receive empirical evidence for a significant impact of the relative allocation of EU emission allowances on the change in (firm level) employment in 2005. For regression no. (7) (as well as (11) and (12)), the estimated coefficient of the allocation factor is positive. However, the magnitude of the coefficient is small and it is not significant at any conventional level. According to economic theory, stringent environmental regulation may induce employment losses, if the output effect of regulation (i.e., lower production and employment levels) dominates the substitution effect (i.e., the shift to a higher labor intensity of production). Our estimation results suggest, however, that firms with a lower allocation factor within the trading scheme did not react with worker layoffs on a net basis.

In regressions (8) to (10), the sign of the estimated allocation factor coefficient changes (for IRLS, again, it is positive in both regressions). However, the coefficients fail to show significance at any conventional level in all equations. In contrast to (1) to (6), the estimated coefficient of the number of employees 2004-2003 is – with a value of about 1 – very high and negative. The coefficient, significant at the 1%-level in each regression, suggests that the lay off of workers in 2004 had a (similar) negative effect on the change of employment in 2005, i.e., the lay off of one worker in 2004 resulted in the lay off of an additional worker in 2005. This may be due to labor market rigidities as well as employment policies of the companies analyzed providing that suspensions were relatively stable over time (2004 to 2005). Sectoral indicator variables have a highly significant impact on employment only using OLS. These results are therefore not very robust over the different econometric specifications, indicating that sectoral affiliation did not necessarily play a role in employment changes in 2005. Furthermore, the interpretation of the individual sectoral dummies is difficult, as the estimated parameters give the deviations of employment changes of the relative sector to those firms that formed part of sectors that were not explicitly modeled. Most other control variables fail to show significance at any conventional level. The effect of revenue as well as of employment development in 2004 on employment development in 2005 is extremely robust concerning both point estimates and statistical significance. This undermines the findings of a positive relationship between 2004 revenue development and 2005 employment as well as of a negative relationship between employment development in 2004 and 2005. At least as far as signs and significance of the estimated parameters is concerned, IRLS results resemble to 2SLS.

2.2.5. Conclusions

This chapter empirically investigates the role of the EU Emission Trading Scheme (EU ETS) for competitiveness and employment at the firm level. We provide an overview over relative allowance allocation within the EU ETS as well as an econometric analysis for a large sample of German ETS firms in order to assessing the economic impacts associated with emission allocation under the EU ETS.

Our calculations suggest that the total EU emission trading scheme was generally long in 2005. The long position is very large in Lithuania, while other countries were short in emission allowances. Regarding the competitiveness effects of EU environmental regulation, we conduct an econometric ex-post regression analysis for Germany which, to our knowledge, is the first of its kind concerning the EU ETS. Following the competitiveness concept "ability to sell", as an empirical indicator of competitiveness we employ firm revenues. As a second economic indicator we use employment levels of the respective firms. Our econometric analysis provides evidence on the fact that the allowance allocation within the EU ETS framework did not have a significant impact on revenues and employment of regulated German firms. Our results thus suggest that for regulated companies the competitiveness impacts of the emission allocation within the first phase of the EU ETS were not pronounced. This finding could be due to the low overall burden of emission regulation within the EU ETS.

Some disclaimers apply to these results. First, it is definitely very early to conduct an ex-post analysis for the EU ETS. In this respect, it is possible that competitiveness effects of this regulation could occur after 2005. Consistent economic firm data at a European level for 2005 or later was not available to us, so that our – first, and, due to the small data set, basic – econometric analysis could only be performed within a case study for Germany, the most important country within the EU ETS according to the verified emissions. Furthermore, ex-post analyses do not have to be restricted to revenues and employment, although these are definitely two factors of great interest in the context of environmental regulation. Other measures of interest may be, e.g., innovation, profits, and international trade effects that could not be tackled within the analysis conducted here. All in all, future empirical research in many directions is needed to complement these first ex-post insights into the effects of regulation according to the EU ETS.

2.3. Clean and Productive? Evidence from the German Manufacturing Industry[13]

2.3.1. Introduction

Will industries that are "greening" gain or loose in productivity? This question is crucial not only for managerial, but also for political decision-making if the policy agenda includes both economic as well as environmental goals. From a theoretical point of view, the question is controversially disputed within two complementary strands of scientific research. First, there is the debate on the economic impacts of environmental regulation, i.e. of policy measures aiming at a greener production: Traditional economic theory predicts negative economic effects of such regulation (Palmer et al., 1995), while the so-called Porter Hypothesis suggests economic gains from regulation due to innovation offsets in the regulated country (Porter and van der Linde, 1995). Second, there is the debate on the economic effects of voluntary measures of businesses that lead to a greener production ("environmental performance") – as with the case of environmental regulation the findings here are ambiguous (Telle, 2006). This chapter picks up both strands of literature: Based on the theoretical framework of a production function approach that particularly accounts for capital inputs serving to environmental goals, we empirically analyze the economic effects of environmental investment and expenditures. Our econometric analysis refers to the German manufacturing industry and is based on the application of panel techniques that capture both unobserved heterogeneity over industries and time as well as dynamic adjustment processes.

There is a substantial literature on possible "innovation offsets" of environmental expenditures and regulation. Brunnermeier and Cohen (2003) find that pollution abatement and control expenditures (PACE) have a positive impact on

[13] This chapter is based on the research paper "Clean and Productive? Evidence from the German Manufacturing Industry", co-authored by Christoph Böhringer, Ulf Moslener, Ulrich Oberndorfer, and Andreas Ziegler (Correspondence is to Ulrich Oberndorfer).

environmental innovation at the U.S. industry level. Other studies such as Lanjouw and Mody (1996) and Pickman (1998) corroborate this result. In contrast, Jaffe and Palmer (1997) do not find empirical evidence for a positive effect of pollution abatement and control expenditures on – overall – innovation activity at the U.S. industry level. There are fewer empirical contributions that investigate the impact of environmental regulation on economic performance or "competitiveness" based on specific indicators such as imports or productivity growth The findings of Ederington and Minier (2003) for the U.S. industry suggest that net imports are positively affected by the level of abatement costs used as a proxy for the stringency of environmental regulation: More stringent environmental regulation thus in turn implies higher imports, i.e. a decline in competitiveness. Gray (1987) uses productivity growth as a competitiveness indicator and does not find a significant impact of pollution abatement costs on total factor productivity growth in his cross-sectional analysis for U.S. industries. In contrast, a recent study undertaken by Hamamoto (2006) suggests that pollution control expenditures measured at the industry level for Japan positively affect total factor productivity growth via a stimulation of R&D investment. Shadbegian and Gray (2005) introduce PACE data into a production function approach at the U.S. plant level for pulp and paper mills, oil refineries, and steel mills. They find that pollution abatement expenditures hardly affect total production but affect negatively the productivity of non-abatement inputs.

All in all, there is no clear empirical answer to the question on economic effects of environmental regulation or expenditures. If positive effects on particular types of innovation (such as environmental innovation) are found, the general economic impacts remain unclear: For example, a stimulating effect of *environmental expenditures* on *environmental innovation* could be accompanied by a crowding out of *conventional*, i.e. *non-environmental innovation* (cp. Jaffe et al., 1995).

In most studies that assess the interrelationship between environmental and economic performance innovation is used as an indicator of both economic as well as environmental performance. Here, a positive effect of environmental management on environmental innovation at the firm level is identified by the bulk of the available studies (e.g. Rennings et al. (2006) for Germany or Frondel et al. (2007) for a set of seven OECD countries). More recently, however, the causal relationship between environmental management and economic performance has been questioned: Seijas Nogareda and Ziegler (2006) argue rather in favour of a complex dynamic interrelationship between these measures. Also, evidence is fading away if economic performance is proxied more directly, e.g. by financial performance. Ziegler et al. (2007a) for Europe and Konar and Cohen (2001) for the U.S. find a positive effect of environmental performance on stock performance. Telle (2006), however, reports contrary results using a Norwegian plant-level panel data set, where he highlights the importance of controlling for unobserved heterogeneity.

Based on a panel data analysis of the German manufacturing industry between 1996 and 2002 set, we try to shed further light on the relationship between economic performance (measured in terms of production growth) on the one hand, and environmental expenditures, regulation and performance on the other hand. The contribution of this chapter is twofold: From an empirical point of view, we provide the first econometric analysis for the German manufacturing industry on the productivity effects triggered by environmental (green) investment as well as environmental and energy expenditures. From a methodological perspective, we demonstrate the usefulness of modern panel data techniques that take into account not only unobserved heterogeneity, but also state dependence, i.e. dynamic adjustment of the dependent variable.[14] Moreover, we take care of possible endogeneity problems – particularly of variables related to environmental regulation and performance (e.g., Seijas Nogareda and Ziegler, 2006) – by using instrumental variable techniques.

The remainder of this chapter is structured as follows: Section 2 briefly summarizes our theoretical production function approach. Section 3 lays out the data and variables employed in our empirical analysis Section 4 deals with

[14] Most of the cited literature on the interaction between environmental and economic performance is based on the application of cross-sectional or static panel data methods.

methodological details. Section 5 provides the estimation results, section six concludes.

2.3.2. Theoretical Background

One main argument to avert the “greening” of industries, particularly by environmental regulation, is that it will harm the regulated industry in its international competitiveness. Although there is no general definition of competitiveness the reasoning behind this argument is straightforward: Under the simple (but strong) assumption of perfectly competitive markets any onesided binding regulation to a firm will impose additional costs, thereby decreasing the firm’s profitability and market share.

Since the notion of competitiveness is not rigorously defined, a less blurry question can be asked about productivity: Will environmental action, i.e. environmental investment or expenditure, render the economy less productive? One can address this issue within a simple production function approach. Let’s assume a production function (*F*) for sector *i* (1,…,N) at time *t* (1,…,T) to produce a quantity (*y*) which depends on the actual inputs (x_k) into the production process as well as on other non-input factors (o_l) such as the macroeconomic, regulatory or market environment:

$$q_{i,t} = F(x_{k,i,t}, o_{l,i,t}) . \qquad (1)$$

The question arises whether all these inputs x_k should (or could) be attributed directly to the productive process. Those parts of expenditures that pursue environmental goals may be considered as non-productive input as opposed to capital and labor used for production (Shadbegian and Gray, 2005). In other words, environment-related inputs such as pollution abatement expenditures could be considered rather as an additional output, in this case abatement.

A major challenge then is to identify environment-related inputs (investments or expenditures) and to determine their productivity effects: In principle, cost components may leave productivity unaffected, have a negative impact on productivity or may positively affect productivity (as stated by the famous Porter Hypothesis – see Porter and van der Linde, 1995).

Adopting (w.l.o.g.) a simple Cobb-Douglas production function where $x_{1\ldots j}^{ENV}$ denotes environment-related inputs while $x_{1\ldots k}^{PROD}$ and $o_{1\ldots l}$ refer to other input expenditures and non-input factors, we can phrase production as:

$$q_{i,t} = \alpha \cdot \prod_{j=1}^{J} \left(x_{j,i,t}^{ENV} \right)^{a_j} \cdot \prod_{k=1}^{K} \left(x_{k,i,t}^{PROD} \right)^{b_k} \cdot \prod_{l=1}^{L} \left(o_{l,i,t} \right)^{c_l} . \qquad (2)$$

Taking the logarithm on both sides and calculating the variation over time yields

$$\dot{q}_{i,t} = \sum_{j=1}^{J} a_j \dot{x}_{j,i,t}^{ENV} + \sum_{k=1}^{K} b_k \dot{x}_{k,i,t}^{PROD} + \sum_{l=1}^{L} c_l \dot{o}_{l,i,t} . \qquad (3)$$

In our econometric analysis, the productivity effects of different inputs – including environment-related inputs $x_{1\ldots j}^{ENV}$ – are empirically tested.

2.3.3. Data and Variables

We use a panel data set which includes all 23 sectors of the German manufacturing industry based on the two-digit NACE codes from 1996 to 2002. Monetary data is measured in prices of 1995. In our estimations, we employ log-log specifications. As a proxy for production growth, the dependent variable of our analysis, denoted $\dot{q}$, is the absolute growth of gross value added (GVA). Growth in sectoral GVA represents the change in the value of goods and services produced by an industry, less the value of the respective inputs. The variable has a sample mean of 223.55 Mio. Euro. The explanatory variables of special interest in our panel data analysis are those associated with environmental regulation and performance ($x_{1\ldots j}^{ENV}$).[15] As a German "analogue" to the U.S. Pollution Abatement Costs and Expenditures (PACE) we draw on environmental expenditure (i.e. expenditures for environmental protection associated with a "greener", less polluting production process) of the German manufacturing industry which is reported by the German Federal Statistical Office. The environmental expenditures include expenditures for the operation of "green" facilities as well as expenditures that stem from non-operational "green" measures such as fees for waste disposal or current costs for environmental protection (expenditures for water protection, air pollution control etc.). With a sample mean of around 400 Mio. Euro per year (see Table A. 9 in the appendix), the environmental expenditures of the German manufacturing sectors represents only a modest cost share as compared to other categories of expenditure (see Figure 2). In the literature, environmental expenditures are often used as a proxy variable for environmental regulation (see introduction). Obviously, this can be problematic in our case: Apart from expenditures due to legal codes and official sanctions, the German data on environmental expenditures also includes expenditures for voluntary pollution control measures. Such costs do not form part, e.g., of PACE in the U.S. Furthermore, Jaffe et al. (1995) argue that even the PACE may not only give costs of compliance with environmental regulation, but include expenditures that improve the final product or at least the efficiency of the production process at the same time. Therefore, the relationship between environmental expenditures and productivity may only partly reflect regulatory impacts, but rather constitute a combined effect of environmental regulation and voluntary environmental measures. Within our analysis, we consider the energy expenditures of the German manufacturing industry as a further explanatory variable. Energy expenditures include expenditures for combustibles, electricity, gas, and heating. A larger part of energy expenditures are due to energy taxes levied by the German State, thereby reflecting regulatory pressure. On average, energy expenditures make up more than twice the environmental expenditures in

[15] In the literature of production function estimation, it is common to incorporate a capital stock that is built according to a perpetual inventory method (cp. Martin, 2002). Due to our short sample period, such a capital stock construction is not feasible for the present analysis, where we simply use investment and expenditure data.

our sample (875 Mio. Euro). Alike their environmental counterpart, energy expenditures are quite heterogeneous across sectors and years.

Finally, we employ the investment data on environmental protection as explanatory variable. Environmental investment covers additive or integrated investment that exclusively or at least predominantly aims at reducing the environmental damages of production. In analogy to environmental expenditures, environmental investment does not only incorporate investment that is a response to environmental regulation, but also voluntary “green” investment. Compared to environmental and energy expenditures, environmental investment is small with a sample mean of around 70 Mio. Euro (see Figure 2). There are larger differences in environmental investment across industries: While the sample minimum amounts to 0.03, the maximum ranges above 540 Mio. Euro. The correlation analysis reveals that amongst the environment-related variables, environmental investment correlates most strongly (and positively) with GVA growth (the correlation coefficient is 0.11 – see Table A. 10 in the appendix).

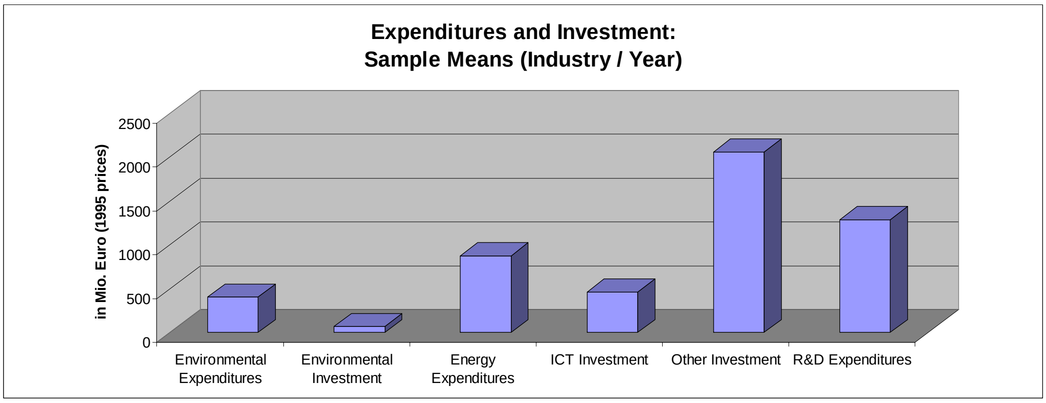

Figure 2 Selected Expenditure and Investment Figures of the German Manufacturing Industry (Source: German Federal Statistical Office and OECD)

Besides environmental investment, energy expenditures and environmental expenditures, we employ several control variables, $x_{1...k}^{PROD}$, for other expenditures and investment. The inclusion of such variables is necessary in order to avoid possible omitted variable biases given that correlation among different expenditure- and investment-measures is generally high. In our data set, environmental investment, expenditures and energy expenditures are in fact strongly correlated with other investment and different cost categories (cp. Table A. 10 in the appendix). Among other expenditures and investment, we account for investment in information and communication technologies (ICT) which is considered as an important driver for sectoral performance and competitiveness (cp. e.g. Jorgenson, 2001). According to our descriptive statistics ICT investment is far higher than environmental investment, with a sample mean of 465 Mio. Euro. Furthermore, we incorporate other investment, i.e. the residual of overall investment minus environmental and ICT investment. On the expenditure side, we include gross salaries (i.e. labor costs) as the most important cost variable of German industries (sample mean: 9490 Mio. Euro) and social security contributions, i.e. the contribution of the employer to the pension fund, unemployment, health, accident, and long term care insurance (sample mean: 2330 Mio. Euro). Moreover, expenditures for research and development (sample mean; 1300 Mio. Euro) are taken into account as a potential productivity driver (Guellec and van Pottelsberghe, 2001).

Besides capital inputs such as expenditures and investment, human capital inputs are also relevant for production. We therefore consider labor inputs measured in terms of hours worked (sample mean: 2.7 Mio. hours per sector and year). Besides the quantity, the quality of labor may play an important role for productivity growth (Redding, 1996). We capture the quality of labor through the share of white-collar employees in each sector which ranges between 23 and 69 per cent of total employees (mean: 38 per cent). Finally, we consider other non-input factors $o_{1...l}$, in particular the intensity of competition. The latter is measured with the Herfindahl-Hirschmann Index (HHI)[16] and the turnover-rate (the share of entering and exiting firms in the total number of firms within an industry). Both variables are included following the hypothesis that highly competitive industries

[16] The HHI is calculated as $HHI_{i,t} = \frac{1000}{A_{n,t}^2} \times \sum_{k=1}^{n} a_{k,t}^2$, with $a_{k,t}$ being the market share of firm k within the respective sector i at time t, and $A_{n,t} = \sum_{k=1}^{n} a_{k,t}$.

may exhibit a higher performance than less competitive ones (Nalebuff and Stiglitz, 1983). All data used in this analysis stems from databases of the German Federal Statistical Office and is publicly available free of charge. Exception is data on ICT investment that is taken from OECD databases.

2.3.4. Methodology

For our econometric analysis, we can build on panel data which offers important advantages vis-à-vis pure time series data or cross-sectional data approaches. Generally, the use of panel data in comparison with both time series and cross-sectional data augments the number of observations that can be evaluated within an econometric analysis. Moreover, it allows for controlling for heterogeneity over sectors (more generally entities) and time as well as for dynamic adjustment processes.[17]

Production growth may be characterized by both time- and industry-specific effects with unobserved time-invariant heterogeneity over the sectors being due to, e.g., sector-specific technologies. The respective estimation approach then reads as

$$y_{i,t} - y_{i,t-1} = \beta' x_{i,t} + t_t + u_i + \varepsilon_{i,t} , \qquad (4)$$

with $\varepsilon_{i,t} \sim \left(0, \sigma^2\right)$, $i = 1,2,...,N$, $t = 1,2,...,T$,

where $y_{i,t}$ denotes production for industry *i* in period *t*, $x_{i,t}$ reflects a vector of *all* current or lagged values of explanatory variables of the same industry, t_t is a time-specific effect common for all sectors, u_i is an unobserved industry-specific time-invariant effect, and $\varepsilon_{i,t}$ is a disturbance term that is independent and identically distributed across industries $i = 1,2,...,N$ and over time $t = 1,2,...,T$.

[17] For overviews on panel data estimation see e.g. Arellano (2003) and Bond (2002).

The standard ordinary least squares (OLS) estimation of the parameter vector β which does not account for time- and industry-specific heterogeneity present in the dependent variable leads to (at least) inefficient results. In case that such time or individual effects correlate with the explanatory variables, OLS is even inconsistent.[18] Therefore, we augment the model by dummy variables for both the time and industry dimension. The resulting model corresponds to the Least Squares Dummy Variable estimator (LSDV) for production growth with both industry- and time-specific effects.[19] Another problem may arise if there is state dependence in present the dependent variable on top of the phenomenon of unobserved industry-specific time-invariant effects, i.e.:

$$y_{i,t} - y_{i,t-1} = \gamma\left(y_{i,t-1} - y_{i,t-2}\right) + \beta' x_{i,t} + t_t + u_i + \varepsilon_{i,t}\,, \qquad (5)$$

with $\varepsilon_{i,t} \sim \left(0, \sigma^2\right)$, $i = 1,2,...,N$, $t = 1,2,...,T$.

Even the LSDV gives inconsistent parameter estimates if applied to such dynamic model: For panels where the number of time periods is small (as in our case with $T = 6$), mean deviation induces correlation between the lagged dependent variable and the error term leading to biased parameter estimates (so-called “Nickell-bias”, Nickell, 1981).[20] Neglection of existing state dependence, however, would again result in a misspecification of the empirical model. We therefore need an approach that accounts for both, unobserved heterogeneity *and* state dependence. Against this background, we make use of a (Nickell) bias corrected LSDV estimator (LSDVC; Bruno, 2005) where results from a consistent estimator deliver the initial values (a bootstrap variance-covariance matrix is calculated). Furthermore, we apply instrumental variable technique in order to solve the problem of the Nickell-bias. The basis for such approach is provided by Anderson and Hsiao (1981, 1982) who propose a Two Stage Least Squares estimator for the first-differenced *AR(1)* panel data model (2SLS DIF; formulated with time effects here):

[18] Note that production growth as the first difference GVA already excludes time-invariant industry-specific effects that could be present in GVA levels.

[19] The use of dummy variables at the industry dimension in order to eliminate unobserved heterogeneity over industries ui is equivalent to using mean-differentiated variables.

[20] Note that the Nickell-bias does not even vanish in samples with a high number of industries.

$$y_{i,t} - y_{i,t-1} = \beta'\left(x_{i,t} - x_{i,t-1}\right) + \gamma\left(y_{i,t-1} - y_{i,t-2}\right) + t_t + \left(\varepsilon_{i,t} - \varepsilon_{i,t-1}\right), \qquad (6)$$

with $\varepsilon_{i,t} \sim \left(0, \sigma^2\right)$, $i = 1,2,...,N$, $t = 1,2,...,T$.

In contrast to industry dummies (or, alternatively, deviations from group means) used by the LSDV, first differences eliminate unobserved sector heterogeneity. This approach yields consistent parameter estimates when lagged levels $y_{i,t-2}$ are uncorrelated with $\left(\varepsilon_{i,t} - \varepsilon_{i,t-1}\right)$ and are used as an instrumental variable for equation (6). The parameter γ denotes the effect of the lagged dependent variable while the parameter vector β measures the effect of the other explanatory variables. For endogenous *x*'s, lagged levels besides other exogenous variables are available as instruments. Environmental, ICT and other investment, environmental, energy, r&d expenditures, social security contributions, gross salaries and hours worked at the sectoral level may not only affect production growth, but may also be caused by the magnitude of production growth of the same period. Possible reverse causality problems may be avoided using instrumental variable techniques to equation (6).[21] If the panel does have more than three time series observations (as in our case), the model is overidentified because there are even more lagged levels available as instruments. It will then be beneficial to make use of the dynamic panel data estimator (GMM DIF) developed by Arellano and Bond (1991), instead of the 2SLS DIF. The GMM DIF is based on the same first-difference transformation as shown in equation (6). However, asymptotically efficient parameter estimates are obtained from a Generalized Method of Moments (GMM) framework which uses a weighting procedure for the instrument matrix. This approach also allows for the instrumentation of endogenous *x*'s. However, the properties of the GMM DIF (as well as those of the 2SLS DIF) hinge on the number on entities (here: sectors) covered by the sample (cp. e.g. Kiviet, 1995). According to Bruno (2005), the LSDVC could be beneficial in comparison with the GMM DIF for small samples such as in our case $N = 23$. In our empirical analysis, we apply OLS, LSDV, LSDVC, and GMM DIF. This serves as an important robustness check and increases transparency of our analysis.

[21] Instrumental variable technique for the LSDVC, in contrast, has not yet been developed.

2.3.5. Results

For all of the four estimation techniques, we report one specification including all explanatory variables, and another one including only the environment- and energy-related variables plus all other explanatory variables that show statistical significance at least at the 10%-level.

For industry panel settings only little confidence is attributed to simple OLS estimation results due to the prevailing sources of bias outlined in previous section. Since production growth as our dependent variable is already the first difference of overall production (GVA), an OLS approach may not perform that bad: sector-specific differences in GVA itself are eliminated in taking first differences. The commonly adopted, more elaborate technique for our problem class, however, is a LSDV estimator which controls for both industry- and time-specific effects.[22] When lagged production growth as an explanatory variable enters into the estimated equation, a dynamic panel approach seems to be more adequate for our setting: The 2SLS DIF estimator yields unbiased parameter estimates, but in contrast to the GMM DIF (we apply) it is not asymptotically efficient given our time series dimension with $T = 6$. Moreover, the LSDVC, which however does not allow for the solution of any endogeneity problem, is applied. For the GMM DIF, none of the diagnostic tests (on first- and second order serial correlation in the residuals as well as the Sargan test on overidentifying restrictions) indicates a misspecification. Furthermore, in this approach we instrument all investment, expenditure and employment variables[23] in order to eliminate possible reverse causality problems. According to specification tests of the first stage regressions, the lags of both first as well as second applied as instruments explain significantly the endogenous variables (see Table A. 12 in the appendix).

[22] The results of an F-Test for industry-specific effects in the LSDV do not suggest, however, that such effects (in contrast to time-specific effects) are already eliminated by taking first differences of GVA in order to generate GVA growth (F-statistic of 0.79 and 1.07, respectively). Therefore, both OLS with GVA growth as dependent variable and the GMM DIF should not suffer from specification problems due to omitted industry dummy variables.

[23] I.e. the variables environmental, ICT and other investment, environmental, energy, R&D, social security contributions, gross salaries and hours worked.

Concerning the explanatory variables of major interest, our results show robustness over all four estimation techniques. For the expenditure figures that are related to energy and the environment, we find only weak evidence for a contribution to production growth of the respective sector. This is especially the case for energy expenditures: OLS, LSDV as well as dynamic panel data approaches using the LSDVC and GMM DIF (Table A. 11 in the appendix) show very small values for the estimated coefficient of energy expenditures which – with the exception of OLS – do not significantly differ from zero. Our estimation results thus do not suggest a significant impact of energy expenditures on production growth in the German manufacturing industry.

The results for environmental expenditures are somewhat different: While our our estimations predominantly yield very small coefficients (partly lacking significance), the LSDV as well as the LSDVC provide significant and positive impacts. The – statistically significant – difference between these LSDV/LSDVC results and the results from the GMM DIF which do not suggest statistical significance of the estimated environmental expenditures parameter might be due to possible endogeneity or reverse causality of the environmental expenditures in our setting: If sectors with higher production growth augment their environmental expenditures, the LSDV and LSDVC (besides OLS) would yield upward biased parameter estimates for this variable (in contrast to the GMM DIF). Since our estimation results go along with such an explanation, endogeneity of the environmental expenditures is plausible and the GMM DIF seems to give the more credible results.

Environmental investment stands out as the only variable with robust positive implications for production growth. Amongst all estimation techniques, there is a positive and statistically significant impact of environmental investment on production growth. In contrast to environmental expenditures, this effect does not seem to be endogenously driven by production growth itself, as GMM DIF results do not significantly differ from the results of other estimation techniques that do not control for such possible endogeneity.

In line with the existing literature, we find a positive impact of ICT investment on production growth. According to our results (except for simple OLS), this effect is much – and significantly from a statistical point of view – stronger than for its environmental counterpart. As far as other investment is concerned, however, we obtain quite robust empirical evidence for a negative (small) effect on production growth.

For expenditures that are not related to energy and the environment – such as R&D expenditures, social security contributions, and gross salaries – we do not find empirical evidence for a statistically significant impact on production growth. The same holds for the Herfindahl-Hirschmann Index (HHI) and the turnover-rate, both employed as variables to control for a possible impact of competition intensity. In contrast, labor positively contributes to production growth (GMM DIF results) – the coefficients of both hours worked and quality of labor significantly enter the estimated equation.

2.3.6. Conclusions

In this chapter, we have analyzed the effect of environmental expenditures, energy expenditures and as well as environmental investment on production growth. Our empirical analysis is based on a production function framework applied to a panel dataset of the German manufacturing industry between 1996 and 2002. Our econometric analysis is based on modern panel data techniques that allow for unobserved heterogeneity over industries and time as well as for lagged adjustment processes of production growth. Furthermore, we take into account possible endogeneity of the explanatory variables making use of their lagged values as instrumental variables.

Our estimations indicate that both environmental and energy expenditures do no affect production growth in German manufacturing industries. Controlling for possible endogeneity of explanatory variables proves to be useful especially concerning the relationship between environmental expenditures and production growth: Our estimation results suggest that environmental expenditures are endogenous – techniques not taking into account such endogeneity yield a positive effect which in reality may stem from a reverse (positive) effect of production growth on these expenditures. In contrast, environmental investment robustly exhibits a positive impact which is however substantially lower than that of ICT investment. The latter finding should not be construed as support for the Porter Hypothesis, stating that environmental regulation spurs competitiveness or likewise competitiveness of the regulated industries. Environmental investment may not necessarily be driven by regulation, but simply indicate voluntary environmental performance of the respective industry. With this view, our results suggest that sectors increasing environmental performance via investment instead of expenditure activities benefit in terms of productivity growth.

While our analysis is no direct evaluation of environmental regulation, it contributes to the empirical assessment of the economic consequences triggered by environmental policy: In order to be compatible with economic goals such as the stimulation of productivity, environmental regulation should rather encourage investment than solely causing additional costs. According to economic theory, this is the case for market based policy instruments that provide more incentives for investment and technological change than command and control measures (Requate, 2005).

Regarding future research, it would be interesting to analyse whether our results also hold for countries other than Germany. Furthermore, as soon as firm-level data becomes available, analysis at the micro level could be insightful.

3. Energy and Economic Performance

3.1. EU Emission Allowances and the Stock Market: Evidence from the Electricity Industry[24]

3.1.1. Introduction

In 2005, the European Union Greenhouse Gas Emission Trading Scheme (EU ETS) was launched. Against the institutional background of the Kyoto Protocol that requires European countries to reduce their greenhouse gas emissions on average by 8 per cent until 2012 compared with 1990 emission levels (UNFCCC, 1997), the EU ETS represents a cornerstone of the EU member states' climate policy. Applying to four industrial sectors in its first phase (2005 to 2007)[25], the ETS covers approximately 46 per cent of the total CO_2 emissions of EU countries. The energy sector, and, at the sub-sectoral level, the electricity industry is the most dominant player within the scheme. Of some 10 000 installations covered, approximately 3600 are affiliated to the power and heating industry. These installations make up 1.2 billion tons of CO_2 emissions within the scheme, while overall ETS emissions do not even reach 2 billion tons (Ellerman and Buchner, 2008).

Although overall allowance allocation in the first phase of the scheme has been qualified as relatively generous by many scholars (e.g., Ellerman and Buchner, 2008, Kettner et al., 2008), since its initiation the EU ETS has led to discussions on potential losses in competitiveness for the companies covered. According to Neuhoff et al. (2006), due to the sequential allocation process of EU ETS, decisions in the power sector are distorted. Moreover, the electricity sector seems to be rather an exception as far as generous allowance allocation is concerned. Buchner et al. (2006) show that this sector has been the only one that faced a net short position already in 2005. The authors attribute the relatively stringent

[24] This chapter is based on the research paper "EU Emission Allowances and the Stock Market: Evidence from the Electricity Industry", authored by Ulrich Oberndorfer. The paper has appeared in Ecological Economics 68 (2009), 1116-1126.

[25] These sectors are energy (e.g., electric power, oil refinement), production and processing of ferrous metals, minerals (e.g., cement, glass), as well as pulp and paper.

allowance allocation for this sector to both the absence of international competition and the assumption of comparably low emission abatement costs in electricity generation.

Previous quantitative studies have assessed the economic implications of the EU ETS predominantly in numerical modeling frameworks. Böhringer et al. (2005) show that the exclusive coverage of energy-intensive installations by the ETS implies that – in the absence of the Kyoto Protocol's project-based mechanisms – the remaining industries outside the ETS have to be regulated by complementary abatement policies in order to meet the national Kyoto targets. This implies that under a generous ETS cap, negative economic effects may be much larger for sectors outside than inside the ETS. Assessing both the economy-wide and the sectoral competitiveness effects of the EU ETS, Alexeeva-Talebi and Anger (2007) argue that the burden on ETS sectors might be minimised even under ambitious caps of the scheme if the project-based mechanisms of the Kyoto Protocol are available and if the EU ETS is linked to other emerging trading systems outside Europe.

Empirical evidence on the economic consequences of EU ETS is, in contrast, rather scant. Demailly and Quirion (2008) provide a case study on the iron and steel industry, suggesting that losses in competitiveness for this sector are small. From a case study for the German electricity industry, Hoffmann (2007) concludes that, while being an important driver for small-scale investments, EU ETS has only limited impact on large-scale investment. Zachmann and von Hirschhausen (2008) analyze the impact of EU Emission Allowance (EUA) price developments on German wholesale electricity prices; they find evidence for an asymmetric cost pass-through in a sense that rising EUA prices affect electricity prices more strongly than falling EUA prices. They attribute this finding to either slowly developing knowledge about EUAs as a cost factor or to a possible exercise of market power by German electricity generators. Anger and Oberndorfer (2008) analyze the impact of relative allowance allocation on both economic performance and employment of German companies using econometric techniques. They do not find evidence for revenue and employment effects of relative allowance allocation. The impact of EUA price developments on firm performance, in contrast, has not yet been analyzed, yet. In this respect, this chapter aims at starting to fill this gap. The focus is on financial market impacts of EU allowance price developments for European electricity corporations, i.e., for firms of the most important EU ETS sector (as measured by its emissions).

In this respect, this analysis represents an early approach of policy evaluation with regard to the scheme: Against the background of stock prices representing discounted cash flows of the respective corporations (Fama, 1970), we assess how the market for EU Emission Allowances (the so-called carbon market[26]) affects the value of corporations covered by the scheme. The EUA price effect is especially relevant to the future development of the EU ETS. Already in the second ETS phase (which started in 2008), regulation by allowance allocation via grandfathering has become more stringent (Schleich et al., 2007). Such development is expected to continue given the climate policy goals of the EU aiming at an emission reduction in greenhouse gases of 20 per cent by 2020 (30 per cent if there is an international agreement committing other developed countries to comparable emission reductions, EU, 2008). As shown by numerical simulations, the stricter the allowance allocation, the higher is the EUA price (cp., e.g., Anger, 2008). This result underlines the importance of knowledge concerning the stock market effects as an indicator of economic effects of EUA price developments. Particularly, if corporations covered by the scheme were upvalued by EUA price rises that indicate stringency of regulation within the ETS, free allowance allocation to these corporations could be questioned: Free allocation can act as a temporary subsidy to support firm balance sheets, which may be justified for sectors to which production cost increases as indicated by EUA price rises may not be passed on to the consumers particularly due to international competition (Hepburn et al., 2006). The values of corporations from such sectors, however, should not increase when the EUA price rises. Apart from policy evaluation with respect to possible EUA price effects on the value of

[26] The markets for certificates such as Certified Emission Reductions (CERs), Emission Reduction Units (ERUs) and Voluntary Emission Reductions (VERs) are also emerging carbon markets; because of the particular relevance of EUAs is the context of this study, these markets are neglected here and “carbon market” is used as a synonym for the market for EU Emission Allowances here.

corporations covered by the EU ETS, the question about how financial markets perceive carbon constraints that may emerge due to ETS regulation has been qualified as very important from a corporate management point of view (Busch and Hoffmann, 2007). This knowledge is particularly important for hedging against EUA price risks, enabling investors to take into account feedback from the stock market when the EUA price moves.

In this chapter, we analyze electricity stock return reactions to changes in EU Emission Allowance prices. We take into account possible differences in such a relationship over time – with respect to the EUA market shock in early 2006 – as well as between corporations. This is particularly relevant to corporations operating in different countries that are marked by differences especially in allowance allocation (and therefore in possibly different initial EUA long / short positions) according to the different National Allocation Plans (NAPs) or in the structure of the respective electricity market, possibly affecting EUA cost pass-through behavior. We investigate whether the relationship between EUA price changes and electricity stock returns is asymmetric, which would be consistent with the EUA effect on German wholesale electricity prices. Additionally, we apply a GARCH approach in order to test whether EUA return volatility and European electricity stock volatility are related. The remainder of this chapter is structured as follows: The following chapter presents the three main hypotheses for our empirical investigation. In chapter three, we highlight our methodological approach; in section four we describe the dataset. Chapter five gives the results of the econometric examination. Chapter six concludes.

3.1.2. Hypotheses

Hypothesis 1: EU Emission Allowance price increases (decreases) positively (negatively) affect electricity stock returns.

Benz and Trück (2006) specify EU Emission Allowances as a factor of production held by the respective firm: EUAs are exhausted for CO_2 emission and removed from the market after utilisation. In this respect, EUA price changes directly change the value of EUAs held and therefore the value of the respective firm (i.e., increase in case of EUA appreciations, and vice versa). Moreover, economic theory, modeling studies as well as the first empirical papers available suggest that the EU ETS and especially developments in the EU carbon market influence cash flows of the companies covered by the scheme. While generally high prices of CO_2 emission could be interpreted as an indicator of stringency of regulation shrinking future cash flows, scholars have argued that under the EU ETS effects could work differently. Following Sijm et al. (2006), profits for the marginal production unit for electricity will rise by the respective CO_2 costs for this unit if Emission Allowances are fully grandfathered. Profit increases for the infra-marginal unit (under full grandfathering) will depend on the carbon intensity of this unit relative to the intensity of the marginal unit, and will consequently be lower than the CO_2 costs for the production unit only if the infra-marginal unit is more carbon-intensive than the marginal unit.[27]

This suggests that, under full grandfathering[28], electricity generators can profit from EU ETS and that the profit increase itself is positively related to the EUA prices. Against this background, expected future cash flows of electricity generators covered by the ETS should rise (fall) with rising (falling) EUA prices, leading to rising (falling) stock returns under the hypothesis of efficient capital markets (if financial markets incorporate news into security prices without delay, e.g., Fama, 1970). It is possible, however, that the amplitude of this effect itself depends particularly on country-specific characteristics such as differences in EUA long / short positions due to country-specific NAPs (i.e., relative allowance allocation) and the structure of the national electricity market in which a corporation operates. Moreover, it is unclear whether such an effect would be stable over time, particularly with respect to the EUA market shock in early 2006 that caused a structural break in the EUA prices (Alberola et al., 2008a).

[27] This reasoning does only hold if emission trading does not lead to a change in the merit order and if the electricity demand response to the price increases induced is not large enough to stop the operation of a set of power generators (Sijm et al., 2006).

[28] Although auctioning of up to 5 per cent of total EUAs was permitted during the first phase of the scheme (2005-2007), the member states made little use of this option. Almost all emission allowances were grandfathered by means of National Allocation Plans.

Hypothesis 2: The relationship between EU Emission Allowance price changes and electricity stock returns is asymmetric.

Zachmann and von Hirschhausen's (2008) estimation results suggest that – at least in Germany – electricity generation businesses can increase their future cash flows in times of rising EU Emission Allowance prices, as these price rises are passed through to the wholesale electricity market. In contrast, cash flows would barely shrink in case of falling EUA prices, as electricity prices seem to respond less strongly to falling in comparison to rising EUA prices. Given this, expected future cash flows and therefore stock returns of European electricity corporations should respond asymmetrically to EUA price developments. However, reasons for an asymmetric cost pass-through are largely unknown – Zachmann and von Hirschhausen (2008) propose market power as well as little knowledge of the recently developed ETS market as explanations – as is the answer to the question whether such an asymmetric cost pass-through applies to the German wholesale electricity market only or to all European electricity markets, including long-term and consumer-specific electricity contracts that are widespread. Against this background, the relationship between EUA price changes and stock returns from electricity corporations could be asymmetric, and these asymmetric effects could be country-specific.

Hypothesis 3: EUA volatility is positively related to electricity stock return volatility.

Not only appreciations and depreciations in levels of the EU Emission Allowances may matter for the market development of electricity stocks. An increase (decline) in volatility in the market for EUAs should render the expectations for future cash flows of the corporations covered more (less) volatile. This issue is of special relevance given the high volatility of the EUA price since the establishment of the EU ETS; hedging against unexpected carbon price fluctuations is an important issue here (Benz and Trück, forthcoming). Moreover, price volatility of stocks is highly relevant to the attractiveness of the respective asset for potential investors. In the context of a simple (μ,σ)-rule (Markowitz, 1952), for instance, both the – desired – expected return and the – undesired – volatility matter to portfolio selection.

3.1.3. Empirical Approach

The main objective of this chapter is to address the impacts of EU Emission Allowance price developments on stock performance of European electricity corporations. For this purpose, on the one hand, we make use of an equal-weighted portfolio of the most important electricity stocks from the Eurozone. On the other hand, we analyze stock returns of these corporations in disaggregated form within the framework of a panel approach, i.e., for a richer dataset and without loss of information due to portfolio aggregation. This allows for identifying firm-specific EUA effects (e.g., with respect to the countries where the corporations analyzed are headquartered), while we have to refrain from analyzing stock return volatility in this framework, as Panel GARCH models are a topic of current econometric research (Cermeno and Grier, 2003).

In order to avoid misspecification of the econometric approach, we include the market return as well as oil, gas, and electricity price changes as control variables into the estimated equations. The relationship between the market return and the returns of single stocks or stock portfolios has its theoretical foundations in the Capital Asset Pricing Model (CAPM; Sharpe, 1964, and Lintner, 1965), suggesting that the reward to risk ratio for any security (such as a stock) in relation to that of the overall market is the decisive factor for the pricing of the respective security. However, the existing literature has also stressed the importance of resource price change variables as determinants of energy stock prices. Manning (1991) for the UK oil industry, Hammoudeh et al. (2004) for its U.S. counterpart, Faff and Brailsford (1999) for the Australian oil and gas sector, and Sadorsky (2001) and Boyer and Filion (2007) for the Canadian energy industry show that besides the market return, the oil and, in some cases, the gas price change may be important drivers of stock returns of energy-related businesses. European energy stocks, according to Oberndorfer (2008), are sensitive to oil, but not to gas price changes. Moreover, Oberndorfer (2008) shows that energy stock volatility is not related to volatility in the resource market.

The inclusion of oil and gas price changes as explanatory variables for electricity stock returns is especially important given the possibility that resource price changes may not only be drivers of energy stock prices, but also of the EUA price itself (e.g., Mansanet-Bataller et al., 2007). In this respect, the exclusion of (statistically significant) resource price variables – as well as of electricity price variables that are affected by the EUA prices themselves (Zachmann and von Hirschhausen, 2008) – may cause severely biased estimates with respect to the effect of the EUA price change on electricity stock returns. This could result in a statistically significant EUA effect that is simply due to impacts of resource or electricity price developments. In this respect, our basic approach with regard to the analysis of the electricity stock portfolio is:

$$r_t = \alpha + \beta_1 r_{m,t} + \beta_2 r_{eua,t} + \beta_3 r_{o,t} + \beta_4 r_{g,t} + \beta_5 r_{e,t} + \varepsilon_t \ . \qquad (1)$$

Here, r_t and $r_{m,t}$ are the returns for the electricity stock portfolio and the market portfolio at the end of period *t* (i.e., between *t*–1 and *t*). Equation (1) additionally includes the change of the EUA price $r_{eua,t}$, the change of the oil price $r_{o,t}$, of the gas price $r_{g,t}$, and of the electricity price $r_{e,t}$. ε_t is the disturbance term with $E(\varepsilon_t) = 0$ and $\text{var}(\varepsilon_t) = \sigma^2$. α and β_1, β_2, β_3, β_4, β_5 besides σ^2 are the unknown parameters that have to be estimated by OLS.

We additionally use a Generalized Autoregressive Conditional Heteroskedasticity (GARCH) application. Models of the GARCH-class (Bollerslev, 1986) are very appealing approaches for the analysis of high-frequent time series in financial markets. The reason for this is the fact that they address the phenomenon of volatility clustering, i.e., of a positive correlation between current and past volatility of asset returns. Amongst those approaches, the use of the GARCH(1,1) model (i.e., a model analogous to an ARMA(1,1) model for the conditional variance of the mean equation error term, jointly estimated with the mean equation itself, here as usual by maximum likelihood) is widespread as it generally sufficiently explains systematic variation of asset price volatility (cp., e.g., Andersen and Bollerslev, 1998). We augment such GARCH(1,1) framework by including EU Emission Allowance, oil, gas and electricity volatility variables into the variance equation. Doing this, we allow for the conditional variance of the ideosynchratic error term of the portfolio to be not only determined by its own dynamics, but also by "external" factors. In this respect, our approach relates to the literature of so-called volatility spillovers (cp., e.g., Hamao et al., 1990) – in our setting from the energy (including the carbon) market to the stock market segment of electricity corporations.

$$r_t = \alpha + \beta_1 r_{m,t} + \beta_2 r_{eua,t} + \beta_3 r_{o,t} + \beta_4 r_{g,t} + \beta_5 r_{e,t} + \varepsilon_t \qquad (2)$$

$$h_t = a + b h_{t-1} + c\varepsilon_{t-1}^2 + d_1 v_{eua,t} + d_2 v_{o,t} + d_3 v_{g,t} + d_4 v_{e,t} \qquad (3)$$

$v_{eua,t}$ represents EUA volatility, $v_{o,t}$ oil volatility, $v_{g,t}$ gas volatility, $v_{e,t}$ electricity volatility. We assume (Student) *t*-distribution for the zero mean error term ε_t. h_t is the conditional variance of the error term. α, β_1, β_2, β_3, β_4, β_5, a, b, c, d_1, d_2, d_3 and d_4 besides h_t are the unknown parameters that are estimated by maximum likelihood.

As indicated, we additionally apply a panel data approach taking into account disaggregate stock returns $r_{i,t}$ of all electricity corporations *i* forming the portfolio, allowing for the use of a much richer dataset in both observations and information compared to a portfolio approach (cp., e.g., Boyer and Filion, 2007). The respective approach can thus be formulated as

$$r_{i,t} = \alpha + \beta_1 r_{m,t} + \beta_2 r_{eua,t} + \beta_3 r_{o,t} + \beta_4 r_{g,t} + \beta_5 r_{e,t} + \varepsilon_{i,t}\,. \qquad (4)$$

Variable definition and parameter estimation via OLS is analogous to equation (1). This basic panel framework is augmented by interaction terms between the

EUA price change $r_{eua,t}$ and country-specific indicator variables in order to take into account country-specific stock market effects of EUA price developments.

Additionally, in all approaches interaction terms between the EUA price change and an indicator variable that takes the value of zero for EUA price decreases (as well as for price changes of zero) and the value of one for EUA price increases are incorporated in order to take into account possible asymmetries in the relationship between the EUA price change and the electricity stock and portfolio returns respectively. Moreover, in the panel approach this variable is also interacted with country indicator variables as described above in order to test for country-specific asymmetries. As a further model extension for all approaches, an interaction term between the EUA price change and an indicator variable for the EUA market shock period in early 2006 and for the period before this market shock respectively are incorporated into the empirical analysis.

3.1.4. Data and Variables

Our analysis covers roughly the first period of the European Union Emission Trading Scheme, with a constraint for the very early ETS phase for which no EU Emission Allowance price data is available: We have a sufficient data basis for the EU Allowance settlement price (and for all other variables) from August, 4, 2005 until June 19, 2007.[29] Given this sample period of barely two years, daily data is the only realistic frequency for our econometric approach as weekly or monthly data would provide too few observations in order to conduct a serious time series analysis. In this respect, we are fully aware of the fact that low frequency data (i.e., weekly or monthly data) is often preferred in comparison to daily data in order to circumvent errors-in-variables problems in terms of irregularities, which is especially due to low – daily – trading (volumes) (cp., e.g., Scholes and Williams, 1977). As electricity corporations in general (and this also

[29] This corresponds to the length of the EUA settlement price time series the European Energy Exchange (EEX), Leipzig, made available to the authors. Generally, it seems difficult to integrate data from late 2007, as EUA prices did barely vary at that period due to the high relative allocation within the scheme.

holds for the corporations considered here) are stocks with high trading volumes, such errors-in-variables problems should be negligible in our setting. EUA settlement price data stems directly from the European Energy Exchange (EEX), Leipzig. This is, together with Nord Pool, European Climate Exchange, and Powernext, the predominant EUA marketplace. EUA price data from EEX, Leipzig, is publicly available for scientific use and free of charge. Moreover, as reported by Mansanet-Bataller et al. (2007), EUA prices have developed very similarly in all marketplaces, so that the choice of marketplace should not be crucial for the analysis. All other series used in our analysis are taken from Datastream (Thomson Financial).

Stock returns of the most important electricity corporations whose business is affected by EU ETS form the dependent variable of our analysis. The return series are analyzed individually (pooled) within a panel data framework, as well as aggregated within an equal-weighted portfolio. For the analysis, we choose electricity corporations included in the Dow Jones Euro Stoxx Utilities Index (as at August 1, 2007), for which financial market (return) data is available for the whole sample period. Corporations whose main business activity is the generation (and distribution) of electricity from renewable resources have been excluded given their low exposure to the ETS regulation. All in all, the corporations forming our stock portfolio are Aem (Italy - IT), British Energy Group (United Kingdom - UK), Eon (Germany - GE), Endesa (Spain - ES), Enel (IT), Energias de Portugal (Portugal - PO), Fortum (Finland - FI), Iberdrola (ES), International Power (UK), RWE (GE), Scottish & Southern Energy (UK), and Union Fenosa (ES). The electricity portfolio return series (as well as all individual stock return series; results available on request) is stationary according to a Dickey-Fuller unit root test (Table A. 13 in the appendix).[30]

As explanatory variable of main interest we include the EUA settlement price change into our analysis. This series reflects the EUA price developments at the EEX, Leipzig. Although future or forward prices are less affected by very short

[30] A unit root test without trend term was conducted for these as well as for all other variables used. According to visual inspection, none of the series exhibits trends.

run demand and supply fluctuations and therefore less noisy in comparison to spot prices (cp. Sadorsky, 2001), we opted for the settlement price instead of an EUA future from the EEX as there is little trade at the future in comparison to the spot market. The use of EUA futures would be very problematic for our analysis relying on daily data given the fact that for a multitude of days included in our sample period, price changes taking the value of zero due to trading volumes of zero would occur. Such a problem is avoided by using the EUA settlement price (change). The EUA price, together with price data of the electricity stock portfolio, is graphically shown in Figure 3. Besides the EUA price change variable as such, an interaction term with an indicator variable that takes the value of zero for EUA price decreases (as well as for price changes of zero) and the value of one for EUA price increases is also applied in order to take into account for possible asymmetric stock market effects from the carbon market.

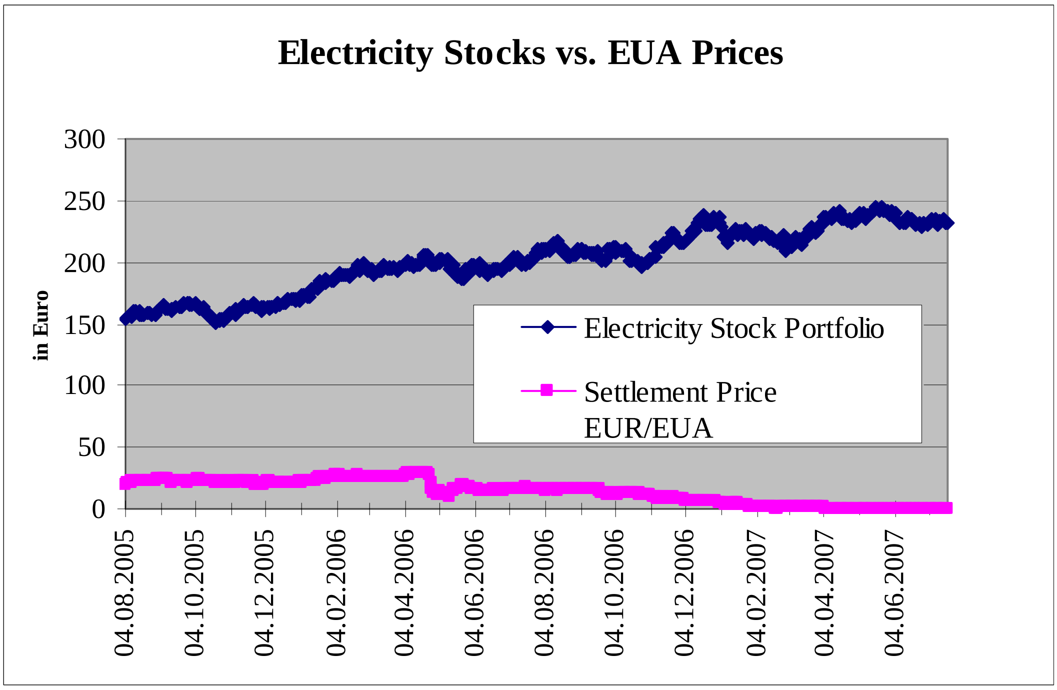

Figure 3 EUA and Electricity Stock Portfolio Price Data for the Sample Period (Source: Datastream / Thomson Financial and EEX)

As indicated in the previous section and shown in Figure 3, the release of emission data revealing long EUA positions in nearly all countries covered by the

EU ETS (Ellerman and Buchner, 2008) evidently led to a fall (without subsequent recovery) in EUA prices from nearly 30 Euro in late April to approximately 10 Euro in early / mid May. We created interaction terms between the EUA price change and an indicator variable taking the value of one for the EUA market shock period in early 2006 (26 April to 10 May, 2006; zero otherwise) as well as for the period previous to this market shock (until 25 April; zero respectively). Moreover, interaction terms between the EUA price change and the dummy variables taking the value of one (zero otherwise) for the country where the respective corporation is headquartered have been generated for the panel analysis. We have created such interaction terms for the corporations stemming from Germany, UK and Italy well as an aggregate indicator variable for the countries with only one corporation in the sample (Portugal and Finland; "others"). This means that in the panel analysis, corporations from Spain constitute the so-called reference category with respect to the EUA effect, to which the interaction terms refer. The choice of the reference category is technically inescapable and does not affect the overall regression results (e.g., Greene, 2003). In addition, the same procedure is followed in order to test for country-specific asymmetric effects.

The market return for our analysis is calculated from the Dow Jones Euro STOXX. It is the broadest market index of the Eurozone stock market, representing large, mid and small capitalisation companies of all Eurozone members. It has a varying number of components (September 2007: 317 corporations). In order to control for a possible impact of oil price changes on the electricity stock returns, we use the (Crude Oil) Brent time series (Euro per Barrel). Brent is the most relevant traded crude for European energy firms. In accordance with existing literature, we use a (one month) forward instead of spot return of this series. Consequently, we use the change of the one month forward natural gas time series from Intercontinentalexchange (ICE, London; Euro per 100 000 British Thermal Units). We choose this time series for natural gas, since gas trading at the EEX, Leipzig, only started in 2007 and EEX gas data is therefore not available for our whole sample period. Besides ICE and EEX, only the APX, Zeebrugge, is another European gas marketplace. However, as gas trading is a very recent activity here as well (since 2005), we opted in favour of the ICE data. The disadvantage of using ICE data, however, is that UK gas prices may be driven by fundamentals of its domestic supply and demand if the UK interconnector to Belgium is full or shut down, so that prices may temporarily decouple from continental gas prices (Kjärstad and Johnsson, 2007). Generally, UK and continental gas prices are, however, closely related due to arbitrage possibilities. The choice of the electricity price series is even more difficult, as no common market for electricity in the EU exists. Although price differences have significantly diminished over the last years, convergence of European electricity prices has not been achieved (Zachmann, 2008). In order to stick most closely to the EUA price data, we opted for the Phelix Month Base from the EEX, Leipzig (Euro per Mega Watt Hour). This series reflects German electricity prices. As Germany is the biggest electricity market in Europe (and the EEX is one of the most liquid European power exchanges, cp., e.g., Zachmann, 2008), German electricity prices may be the best available proxy for overall European electricity price developments.

In order to analyze whether EUA volatility and electricity stock return volatility are related, we incorporate different volatility variables in our framework. As explanatory volatility variables, we include the squared EUA, oil, gas, and electricity price changes into our empirical approach. These volatility variables are constructed in a very similar way compared to Hamao et al.'s (1990) "volatility surprises" from stock markets: The authors use the squared residuals from estimated augmented market models for the respective markets as volatility terms. However, given the fact that price changes from the energy market (which we consider instead of stock markets in Hamao et al., 1990) are generally not explained by an (augmented) market model, our approach seems more adequate for this special setting.

A look at the correlations between the variables considered in this analysis reveals that the dependent variable is strongly and positively related to the market excess return (Table A. 14 in the appendix). The correlation between EUA price change and electricity stock portfolio return is positive as well. Amongst the explanatory variables, the EUA price change correlates relatively strongly with resource price returns, underpinning the findings of Mansanet-Bataller et al. (2007). The absolute values of the correlation coefficients are modest, though, so that multicollinearity should not be too severe in our setting.[31]

3.1.5. Results

Basic Specification and Asymmetries

Estimating Equation (1) and (4), we mostly obtain the results we expected (Table 5). They suggest a highly significant positive impact of the market return on electricity stock returns (with an estimated beta factor smaller than one). For oil, gas, and electricity price changes, however, no clear evidence for the direction of the impact on electricity stock returns (or, respectively, for an impact at all) is indicated. The findings particularly of the panel analysis, indicating a negative effect of oil price changes, are consistent with the previous literature on energy stocks. According to different specification tests reported in Table 5, there is no indication of any misspecification of our empirical approach.

Results of all specifications reported in Table 5 are consistent with Hypothesis 1 formulated above and therefore provide empirical evidence for a positive impact of the EUA price change on electricity stock returns. Regressing the above described electricity stock portfolio return on the full set of explanatory variables (Equation (1)) yields a statistically even highly significant coefficient for the EUA price change variable. This result holds when making use of a Pooled OLS panel specification (Equation (4)). The value of the estimated EUA coefficient (0.01 to 0.02 for all settings) is modest. According to an F-Test, the null hypothesis of no Fixed (i.e., corporation specific) Effects cannot be rejected at any conventional level for this and all following specifications, indicating that Pooled OLS gives

[31] Some of the correlations between energy price variables are lower than expected, particularly between the gas price change and both the oil and electricity price change, respectively. One reason for this finding may be the fact that gas prices observed at European energy exchanges seem to be rather neglected by financial market agents, probably due to the widespread use of long-term gas contracts (e.g., Siliverstovs et al., 2004, Oberndorfer, 2008).

consistent and efficient results. We therefore refrain from reporting Fixed Effects estimation results.

Table 5 Results Basic Specification and Asymmetries

	(1)	**(4) Pooled OLS**	**(1)Asymmetry**	*(4) Pooled OLS Asymmetry*
α	0.00	0.00***	0.00	0.00**
	(0.00)	(0.00)	(0.00)	(0.00)
β_1 (Market)	0.74***	0.74***	0.73***	0.74***
	(0.04)	(0.02)	(0.05)	(0.02)
β_2 (EUA)	0.02***	0.01***	0.02**	0.01**
	(0.01)	(0.00)	(0.01)	(0.00)
β_3 (Oil)	0.04*	-0.01*	0.04*	-0.01
	(0.02)	(0.01)	(0.02)	(0.01)
β_4 (Gas)	0.01*	0.00	0.01*	0.00
	(0.01)	(0.00)	(0.01)	(0.00)
β_5 (Electricity)	-0.00	0.00**	-0.00	0.00**
	(0.00)	(0.00)	(0.00)	(0.00)
δ (Asymmetric EUA)	-	-	-0.00	0.00
			(0.01)	(0.00)
Obs.	481	5772	481	5772
R-squared	0.34	0.19	0.34	0.19
F-Test	61.72***	273.75	41.53***	228.14***
Wald-Test (Chi-sq.)	-	-	-	-
ARCH (Chi-sq.)	0.04	-	0.04	-
BG-Autoc. (Chi-sq.)	0.33	-	0.34	-
Durb. Autoc. (Chi-sq.)	0.33	-	0.33	-
RESET-Test	1.44	-	1.42	-

Note: Standard errors in brackets (OLS estimations: White heteroskedasticity-robust s.e.). *, ** and *** show significance at the 10%-, 5%-, and 1%-level, respectively. None of the specification tests indicates misspecification.

Whereas generally EUA price changes affect stock returns of European electricity corporations, we do not find evidence for an asymmetric reaction of electricity stock returns to EUA price changes. In contrast to the results provided by Zachmann and von Hirschhausen (2008) suggesting asymmetric responses of wholesale electricity prices to EUA price changes, and in contrast to Hypothesis 2, such an asymmetric relationship cannot be observed in the stock market. An interaction term between a dummy variable taking the value of one when EUA price changes are positive (and zero otherwise) and the EUA price change itself added to Equation (1) does not yield any statistical significance. This result is unaffected by the elimination of insignificant explanatory variables.[32]

GARCH-Approach and Market Shock

The highly significant positive EUA effect on the electricity stock portfolio returns also holds when using a GARCH approach. The specification based on Equation (2)/(3) allows for identifying the structure of the Equation (1) error term's conditional variance by its own dynamics and "external" factors (spillovers from other markets). The results from Equation (2)/(3) suggest, however, that electricity stock return volatility is not related to EUA price (change) volatility (Table 6). Moreover, we get no evidence for a statistically significant effect of oil, gas, and electricity market volatility on electricity stock volatility. This result is not affected by excluding statistically insignificant control variables from the empirical framework. In this respect, Hypothesis 3 suggesting a positive relationship between EUA volatility and electricity stock return volatility is not supported by the empirical results. Moreover, the results of an ARCH LM test do not indicate that volatility clustering is present in the electricity stock portfolio, so that the formulation of a GARCH approach is not beneficial in comparison to OLS.

In contrast, independently of basing the analysis on Equation (1), (2)/(3), or (4), we find evidence for a particularly strong impact of EUA price changes on electricity stock returns during the period of market shock in April / May 2006, when EUA prices fell from nearly 30 Euro to approximately 10 Euro in a few days only. During these days, the EUA effect is shown to be highly significantly stronger than later on during the sample period. In contrast, no statistically significant difference in the EUA effect during the pre-market shock period compared to the period after the shock can be shown. Moreover, the volatility analysis has not shown to be sensitive to the EUA market shock. Corresponding

[32] The missing evidence for asymmetry in the relationship between EUA price changes and electricity stock returns has also proved robustness over different approaches in modeling such asymmetry. For brevity, only the specification lined out in chapters III and IV has been reported here. All other regression results, including specifications from which insignificant explanatory variables have been excluded, are available on request.

results have not been included in the manuscript, but are available from the authors on request.

Table 6 Results GARCH Specification and Market Shock

	(2)/(3) GARCH (1,1)	**(2)/(3) GARCH (1,1) Market Shock**	**(1) Market Shock**	*(4) Pooled OLS Market Shock*
Mean Equation				
α	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00*** (0.00)
β_1 (Market)	0.74*** (0.04)	0.74*** (0.04)	0.73*** (0.04)	0.74*** (0.02)
β_2 (EUA)	0.02*** (0.01)	0.01* (0.01)	0.01** (0.01)	0.00* (0.00)
β_3 (Oil)	0.04* (0.02)	0.04 (0.02)	0.04 (0.02)	-0.01 (0.01)
β_4 (Gas)	0.01 (0.01)	0.01 (0.01)	0.01* (0.01)	0.00 (0.00)
β_5 (Electricity)	-0.00 (0.01)	-0.00 (0.01)	-0.00 (0.00)	0.00* (0.00)
γ_1 (EUA Pre-Market Shock)	-	0.05 (0.03)	0.04 (0.03)	0.02 (0.01)
γ_2 (EUA Market Shock)	-	0.04* (0.02)	0.03*** (0.01)	0.03*** (0.01)
Variance Equation				
a	-14.57*** (0.54)	-14.71*** (3.65)	-	-
b (GARCH (1) Term)	0.96*** (0.04)	0.96*** (0.04)	-	-
c (ARCH (1) Term)	0.03 (0.02)	0.03 (0.02)	-	-
d_1 (EUA Volatility)	10.15 (14.91)	11.99 (13.22)	-	-
d_2 (Oil Volatility)	1177.74 (1468.04)	1245.85 (1516.15)	-	-
d_3 (Gas Volatility)	14.21 (52.63)	12.87 (61.25)	-	-
d_4 (Electricity Volatility)	16.11 (15.08)	16.56 (15.93)	-	-
Obs.	481	481	481	5772
R-squared	-	-	0.35	0.19
F-Test	-	-	46.02***	196.01***
Wald-Test (Chi-sq.)	846.86***	305.43	-	-
ARCH (Chi-sq.)	-	-	0.05	-
BG-Autoc. (Chi-sq.)	-	-	0.55	-
Durb. Autoc. (Chi-sq.)	-	-	0.54	-
RESET-Test	-	-	1.30	-

Note: White heteroskedasticity-robust standard errors in brackets *, ** and *** show significance at the 10%-, 5%-, and 1%-level, respectively. None of the specification tests indicates misspecification.

Country-Specific EUA Effects

Analyzing disaggregated electricity stock returns within a panel data framework suggests that the EUA effect on the stock market is country-specific. An F-Test on the joint significance of country interaction terms with the EUA price change (Table 7) leads to the rejection of the null hypothesis of no country-specific EUA effects at any conventional level. In this setting (column 1), Spanish electricity corporations as the baseline even exhibit a significantly (but small as far as the size of the estimated coefficient is concerned) negative relationship between EUA price changes and stock returns. The relationship for electricity corporations from all other countries covered significantly differs from this. All country-specific EUA interaction term coefficients are positive and significantly differ from zero at least at the 5%-level, and their absolute values suggest an overall positive EUA effect for nearly all countries considered. The coefficient is highest for the UK corporations covered. Also the market shock interaction term coefficient remains highly significant in this setting.

Table 7 Results Country-Specific EUA-Effect

	(4) Pooled OLS Country-Specific EUA Effect	*(4) Pooled OLS Country-Specific EUA Effect and Asymmetry*
α	0.00*** (0.00)	0.00* (0.00)
β_1 (Market)	0.74*** (0.02)	0.74*** (0.02)
β_2 (EUA)	-0.01** (0.00)	-0.02*** (0.01)
β_3 (Oil)	-0.01 (0.01)	-0.01 (0.01)
β_4 (Gas)	0.00 (0.00)	0.00 (0.00)
β_5 (Electricity)	0.00* (0.00)	0.00* (0.00)
γ (EUA Market Shock)	0.03*** (0.01)	0.03*** (0.01)
θ_1 (EUA Germany)	0.02*** (0.01)	0.03*** (0.01)
θ_2 (EUA United Kingdom)	0.03*** (0.01)	0.03*** (0.01)
θ_3 (EUA Italy)	0.01** (0.01)	0.02** (0.01)
θ_4 (EUA Other)	0.02** (0.01)	0.02** (0.01)
δ (Asymmetric EUA)	-	0.01 (0.01)
κ_1 (Asymmetric EUA Germany)	-	-0.01 (0.02)
κ_2 (Asymmetric EUA United Kingdom)	-	-0.01 (0.02)
κ_3 (Asymmetric EUA Italy)	-	-0.01 (0.01)
κ_3 (Asymmetric EUA Other)	-	-0.00 (0.02)
Obs.	5772	5772
R-squared	0.19	0.19
F-Test	139.70***	93.81***
F-Test on country-specific interaction terms	5.02***	-
F-Test on country-specific asymmetry interaction terms	-	0.56

Note: White heteroskedasticity-robust standard errors in brackets *, ** and *** show significance at the 10%-, 5%-, and 1%-level, respectively. None of the specification tests indicates misspecification.

In contrast, there is no evidence for an asymmetric effect of the EUA price change on electricity stock returns for any of the countries represented in our sample. None of the coefficients referring to such an asymmetric effect shows significance at any conventional level. Moreover, an F-Test on the joint significance of country interaction terms with the asymmetric EUA price change does not indicate the presence of such asymmetric effects.

3.1.6. Conclusions

This chapter constitutes – to our knowledge – the first econometric analysis on stock market effects of the EU Emission Trading Scheme. We analyze electricity stock return reactions to changes in EU Emission Allowance prices, taking into account possible asymmetries in the relationship between EUA price changes and electricity stock returns, as well as country- and time-specific effects. Moreover, within the framework of a GARCH approach we test whether EUA return volatility and European electricity stock volatility are related. Our results suggest that EUA price increases (decreases) positively (negatively) affect stock returns from the most important electricity corporations covered by the EU ETS. In this respect, the electricity corporations considered are upvalued in case of an EUA appreciation, and downvalued in situations where the price of EU Emission Allowances falls. However, the effect differs from country to country: Amongst the electricity corporations considered, Spanish corporations are shown to exhibit a negative EUA to stock market relationship. In contrast, the effect is positive for corporations from other countries such as Germany and the UK. Stock markets do not seem to react differently to EUA appreciations in comparison to depreciations. Moreover, electricity stock return and EUA price change volatility are not shown to be positively related.

Given these results, it becomes apparent that EU ETS effectively has an impact on financial (stock) markets and therefore has economic consequences, affecting the value of the corporations covered. While Anger and Oberndorfer (2008) cannot show economic impacts of relative EU Emission Allowance allocation, price developments of the EUA market matter from an economic and financial market point of view, a finding that may be important for investors, e.g., seeking to hedge against EUA price risks. The first ETS phase seems to be marked at least to some extent by uncertainty of financial market agents concerning the importance of the newly created EU carbon market for the stock market: The EUA effect on electricity stocks is shown to vary over time, being especially high during the EUA market shock in early 2006. Such a “premium” on the EUA effect could be based on the exceptionally high attention of the general public (and seemingly also of stock market agents) to the carbon market at that time. In this respect, the results shed new light on Zachmann and von Hirschhausen’s (2008) claim of slowly developing knowledge concerning the European Emission Allowances amongst financial market agents.

The fact that EUA price changes positively affect European electricity stocks (at least for most countries analyzed) is the consequence of fully rational electricity pricing under a grandfathering allocation rule if pass-through for costs created by the ETS is possible: Against the background of the European carbon market, opportunity costs of fossil power generation according to the EUA price exist. Due to the design of the scheme with almost 100 per cent of Emission Allowances grandfathered instead of auctioned in the first phase and (initial) EUA long positions for most of the companies covered by the scheme, an increase in future cash flows of electricity firms in case of an EUA appreciation is straightforward, with positive stock market reactions as a logical consequence. This result, however, calls into question free allowance allocation to these corporations, as free allocation is seen as an instrument to support firms suffering from production cost increases generated by EUA price rises (Hepburn et al., 2006).

At least German electricity wholesale prices seem to react asymmetrically to EUA price changes in that rising EUA prices have a stronger impact on electricity prices than falling EUA prices (Zachmann and von Hirschhausen, 2008). However, stock markets do not seem to consequently react asymmetrically in the pricing of electricity stocks. One possible explanation of this result may be the stock market agents’ ignorance of the asymmetric cost pass-through in the electricity market. Alternatively, it is unclear whether such asymmetry in the EUA price to electricity price relationship only relates to the German electricity exchange or to European electricity markets as a whole, where also customerspecific long-term contracts play an important role. This has not yet been shown. However, even for the German corporations considered, there is no indication of asymmetric stock market effects. Finally, we do not find a significant effect of EUA volatility on stock volatility for the corporations covered by the ETS, even against the background of a relatively volatile EU carbon market (Benz and Trück, forthcoming). This may weaken the widespread argument stating that volatility shocks from the EUA market may create economic damage to the corporations covered by the scheme and deteriorate the performance of the EU ETS in comparison with EU-wide taxes (Baldursson and von der Fehr, 2004). Future research, however, may provide additional insights into this relationship, e.g., by the application of multivariate GARCH models (Bauwens et al., 2006). The "inverse" EUA effect for the Spanish corporations could stem from stringent price regulation at the Spanish electricity market, where cost pass-through, in contrast to the electricity markets in other European countries, is not possible. Another factor driving this result could be the relative allocation with EU Emission Allowances, resulting from characteristics of the Spanish NAP: According to Kettner et al. (2008), the Spanish power and heat sector was, amongst its counterparts from other European countries, the one with the largest short position.

Generally, our results refer to the current design of the scheme with almost 100 per cent of Emission Allowances grandfathered instead of auctioned, to an emission cap that is in general assessed to be rather generous (e.g., Ellerman and Buchner, 2008, Kettner et al., 2008), and to the power sector that is suspected to be able to pass through costs very easily to the consumers. Because of those phenomena, the ETS has been suspected of generating windfall profits for many companies covered (Sijm et al., 2006). However, a much stronger emission cap in the second compared to the first phase, as it is expected from early analysis of the National Allocation Plans of the ETS member states (Betz et al., 2006, Schleich et al., 2007), may also increase economic consequences of emission regulation under the EU ETS. While our results suggest that a long-term EUA price rise in the future could benefit electricity corporations to which the ETS applies, this should particularly come true if the EUA price rises were to be anchored in more stringent (free) allowance allocation for corporations outside the electricity sector. However, as the EU’s (2008) recent plans suggest full auctioning for the power sector in 2013 – first evidence for such development is the rise of the auctioning limit to 10 per cent in the second EU ETS phase (in comparison to 5 per cent in the first phase) – possible benefits as suggested by the results of the empirical analysis seem to be at least temporally restricted. It will be interesting to see whether positive stock market reactions to EUA price rises will occur under such new climate policy regime. Again, however, benefits (or losses) for infra-marginal units will depend on the extent of EUA cost pass-through as well as their carbon intensity relative to the intensity of the marginal unit. The possibility of reduced benefits or even losses of electricity generators in case of EUA price rises is underlined by the evidence for Spanish electricity corporations, where cost pass-through is restricted and allowance allocation was least generous in the first phase.

This chapter is among the first empirical contributions to the question of economic impacts of the European Union Emission Trading Scheme. Econometric analysis with respect to EU ETS is just evolving. Additional insights into EUA prices (cp. Alberola et al., 2008a and b, Mansanet-Bataller et al., 2007, or Benz and Trück, forthcoming) will be needed for the second EU ETS phase that started in 2008. Also the EUA impact on electricity and stock prices should be further examined; here it would be particularly interesting to assess whether or how electricity generators’ portfolios of power plants affect their stock returns’ relationship to the EU Emission Allowance market. Related issues that have to be tackled in order to complement the existing literature are widespread: Of particular interest will be the analysis of ETS impacts on industry relocation, trade flows, and (environmental) innovation against the background of the pollution haven (Cave and Blomquist, 2008) as well as the Porter hypothesis (Porter and van der Linde, 1995, and Frondel et al., 2008).

3.2. Resource Prices, Volatility, and the Stock Market: The Case of Eurozone Energy Corporations[33]

3.2.1. Introduction

The recent years have been marked by massive price movements at the resource markets. Prices at the international energy exchanges have been rising strongly, and record high prices for oil and natural gas have been accompanied by non-negligible volatility. Energy price, but also price volatility hikes have been shown to be economically detrimental (e.g., Ferderer, 1996, and Sadorsky, 1999). Overall stock market developments are no exception to this rule. Against this background, the recent public attention not only to energy prices, but also to the volatility at the energy markets is not surprising, with oil price volatility being relatively high also compared to volatility of other commodities (Regnier, 2007).

From previous literature, however, it is also apparent that the stock market effects of resource price developments may depend on the sectoral affiliation of the respective corporation analyzed. Particularly energy corporations are often said gaining from resource price increases. The role of resource price volatility has not yet been explored in this context. Generally, stock market developments of corporations from the energy branch are a very interesting case. This is due to the fact that the sector itself is marked by several peculiarities. Many of the inputs this sector uses and of the outputs it produces are both homogenous and traded at international exchanges. The prices of some of these goods – resources such as oil and gas – are extremely volatile, and the U.S. Dollar is the predominant currency for their trading. Moreover, capital intensity of the industry, compared to other sectors, is high (Sadorsky, 2001).

[33] This chapter is based on the research paper "Resource Prices, Volatility, and the Stock Market: The Case of Eurozone Energy Corporations", authored by Ulrich Oberndorfer. The paper has been accepted for publication in Energy Policy.

In the light of such possible interactions of different financial markets, it is surprising that there is relatively little literature on the determinants of energy corporations' stock performance. Moreover, to our knowledge, for European markets as a whole only Manning's (1991) study assessing UK oil industry stock portfolios is available. Evidence from continental Europe is completely missing. According to the main result from Manning's research – using an market model plus oil price change for weekly data – a positive effect of oil price changes on oil corporations' stock returns exists. This effect is largest for corporations purely engaged in oil exploration and production. Faff and Brailsford (1999) analyze the Australian stock market analogously using a model including an "oil factor" besides the well-established market (beta) factor. With respect to the oil and gas sector that is in the focus of our research question, the authors find a positive impact of oil price changes on stock returns on a monthly basis.

Most recent and comprehensive research as far as returns of energy stocks are concerned has been conducted for Canada. Sadorsky (2001) develops an extensive model including the market excess return, an interest variable based on the term premium, the change of the Canadian Dollar to U.S. Dollar exchange rate, as well as oil price changes. His estimations show that each of these variables plays a statistically significant role in explaining returns from a stock portfolio of Canadian oil and gas corporations. While the market excess return and the oil price change positively impact on portfolio returns, Sadorsky's (2001) results indicate that increases in both the exchange rate and the term premium lower Canadian oil and gas stock returns. Their results with respect to an estimated beta coefficient smaller than one furthermore suggests that the Canadian oil and gas industry is on average less risky than the market. Similarly focussing on Canadian oil and gas corporations, Boyer and Filion (2007) contribute to these findings in adding gas price changes as a factor of stock returns as well as in incorporating firm-specific financial and operational characteristics ("fundamental factors") such as cash-flows and production volume. As the most surprising result from their analysis based on monthly data, Boyer and Filion find that firm production negatively affects stock returns.

As far as the determinants of energy stock returns are concerned, the previous literature is largely restricted to the impact of (amongst others) resource prices. Given the background of negative macroeconomic effects of resource price volatility, and Sadorsky’s (2003) finding that even technology stocks seem to be driven by oil price volatility, it is very surprising that the relationship between energy market volatility and energy stocks has, to our knowledge, been ignored so far. In contrast, energy stock returns as well as their volatility may also be influenced by resource price volatility.

In this respect, the contribution of this chapter is twofold: We conduct a first analysis on the determinants of stock returns of energy corporations from the Eurozone, focussing on the role of the energy market for the stock market. For this purpose, we examine two different portfolios of energy stocks: One portfolio consisting of oil and gas corporations’ and one portfolio comprising utilities’ stocks. Particularly, within our empirical approach, we tackle the issue of relationships between resource price volatility and energy corporations’ stocks. The remainder of this chapter is structured as follows: Section two presents the background including the main hypotheses for our empirical investigation. Section three gives the empirical analysis; section four concludes.

3.2.2. Background

Using a simple illustration, Chen et al. (1986) argue that macroeconomic variables systematically affect stock returns. It is based on the representation of stock prices of corporation *i* (p_i) as expected future cash flows of the corporation ($E(cf_i)$) that are discounted by the discount rate δ

$$p_i = \frac{E\left(cf_i\right)}{\delta}, \tag{1}$$

implying stock returns of corporation *i* of

$$\frac{dp_i}{p_i} = \frac{d\left[E\left(cf_i\right)\right]}{E\left(cf_i\right)} - \frac{d\delta}{\delta}. \qquad (2)$$

In this respect, following Chen et al. (1986), the systematic forces of the stock returns of corporation *i* should be both changes in the discount rate δ and in the expected future cash flows $E(cf_i)$.

Given rising oil and gas prices, the resource stocks of companies related to oil and gas business or their products and services should be upvalued. Consequently, their expected future cash flows should rise. Resource price collapses, in contrast, should be economically harmful for them (Hampton, 1995). European utilities use oil and – to a much larger extent – gas and coal as an input for electricity generation (EIA, 2007) or sell them directly to their clients. Although at least some of the utilities are supposed to exhibit non-negligible market power and electricity consumption is considered to be relatively inelastic, it is unclear whether costs stemming from resource price increases can fully and immediately be passed on to the consumers. Rising (falling) resource prices should therefore reduce (increase) utilities' expected future cash flows.

Following the existing literature, energy price variables – besides the market return – are the most important determinants of energy stock returns. However, not only appreciations and depreciations in levels of resources may matter for the market developments of energy stocks. Sauter and Awerbuch (2003) argue that since "the 1980s, oil price volatility is more significant in its effects on economic activity than the oil price level". Despite the existence of energy options, the energy industry is strongly exposed to energy price risks (Hampton, 1995). Therefore, energy market volatility may equally impact on the discounted expected future cash flows of energy corporations. Resource market volatility may cause augmented expenditures for affected corporations, and may, e.g., induce hedging costs for oil and gas corporations as well as for utilities. Moreover, following Pindyck (2004), an increase in price volatility may decrease the production of the respective commodity. Energy price volatility should therefore negatively affect expected future cash flows particularly of oil and gas corporations, but also of utilities.

3.2.3. Empirical Analysis

Empirical Approach

Our goal is to test the predictions lined out in the preceding section for Eurozone energy stock returns using two portfolios based on stock returns of utilities on the one hand, and of oil and gas corporations on the other hand. In line with the existing literature from outside of the Eurozone, this is done in a following framework:

$$r_{i,t} = \beta_i ' X_{i,t} + \varepsilon_{i,t} \,. \qquad (3)$$

Here, $r_{i,t}$ is the excess returns for portfolio *i (i=1,2)* and at the end of period *t* (i.e., between *t*–1 and *t*) over the one month T-bill rate. β_i is the parameter vector of the model, and $X_{i,t}$ a vector containing the explanatory variables of the model. $\varepsilon_{i,t}$ is the disturbance term with $E(\varepsilon_{i,t}) = 0$ and $\mathrm{var}(\varepsilon_{i,t}) = \sigma_i^2$. The parameter vector β_i besides σ_i^2 have to be estimated by OLS. The important choice for this model relates to the explanatory variables to be considered. First of all, $X_{i,t}$ includes the market excess return $r_{i,t}$. This is based on (and compatible to) the Capital Asset Pricing Model (CAPM, Sharpe, 1964 and Lintner, 1965), that assumes that the market excess return is sufficient to explain the excess returns of the portfolios, i.e., that the market excess return is the only relevant risk factor.

We extend this model by those variables that have shown to influence Canadian energy stock returns: We add the price changes of the term premium $r_{r,t}$, of the

Euro to U.S. Dollar exchange rate $r_{x,t}$ [34] (Sadorsky, 2001), as well as of energy prices: For both the utilities and the oil and gas portfolio, we add price changes of oil $r_{o,t}$, and of gas $r_{g,t}$ (Boyer and Filion, 2007) to $X_{i,t}$. As particularly coal is an important input for electricity generation in Europe, in case of the utilities analysis also the change to the coal price $r_{c,t}$ is added. Additionally to the models established in the existing literature, we enrich $X_{i,t}$ by adding the volatilities of the changes in the oil price $v_{o,t}$ (or $w_{o,t}$ and $z_{o,t}$, see below) and in the gas price (and, for the analysis of the utilities portfolio, volatilities of the changes in the coal price).

In a next step, we additionally base our analysis on a Generalized Autoregressive Conditional Heteroskedasticity (GARCH) application. Models of the GARCH-class (Bollerslev, 1986) are very appealing approaches for the analysis of high-frequent time series in financial markets. Reason for this is the fact that they address the phenomenon of so-called volatility clustering, the tendency that current volatility of asset returns tends to be positively correlated with its past values. Amongst those approaches, the use of the GARCH(1,1) model (i.e., a model analogous to an ARMA(1,1) for the conditional variance of the mean-equation error term that is jointly estimated with the mean equation itself, here as usually by maximum likelihood) is widespread as it generally sufficiently explains systematic variation of asset price volatility (cp., e.g., Andersen and Bollerslev, 1998). We assume normal distribution for the error term $\varepsilon_{i,t} \sim N(0, h_{i,t})$.

$$r_{i,t} = \beta' X_{i,t} + \varepsilon_{i,t} \tag{4}$$

$$h_{i,t} = a_i + b_i h_{i,t-1} + c_i \varepsilon_{i,t-1}^2 \tag{5}$$

Data and Variables

The sample period of our analysis ranges from January, 1, 2002 until August 15, 2007. Due to this relatively long period, our research question can be analyzed in

[34] Analogously to the Canadian Dollar to U.S. Dollar exchange rate in Sadorsky's (2001) analysis for Canadian energy corporations.

terms of daily data with a sufficient number of observations. In this respect, we are aware of the fact that low frequency data (i.e., weekly or monthly data) is often preferred in comparison to daily data. In case of low – daily – trading, daily data may induce errors-in-variables problems (Scholes and Williams, 1977). However, such irregularities should not occur in our setting given the fact that the corporations forming our portfolios are "big" stocks with high trading volumes. Moreover, volatility clustering, a statistical phenomenon that often occurs in daily data sets and that may render OLS estimations misspecified, is captured by this analysis within the GARCH-approach.

The sample period is defined in a way that common interest rates and exchange rates from the Eurozone exist and are valid for all corporations from this region. Such common interest and exchange rates have been introduced already in 1999. In order to avoid data problems due to early adjustments (of interest and exchange rates) in the phase of Euro introduction, we set the starting point of the sample period to January, 1, 2002, when physical Euro coins and banknotes were introduced. All series used in our analysis stem from Datastream (Thomson Financial). We analyze the returns of two different sub-sectoral portfolios of Eurozone energy stocks. We label the first portfolio oil and gas portfolio. It is the equal weighted portfolio of the most important Eurozone oil and gas business-related corporations' stock excess log returns. The second – the utility portfolio – is the equal weighted portfolio of the most important publicly traded Eurozone utilities' stock excess returns.

We identify the corporations considered for the oil and gas portfolio by choosing all corporations included in the Dow Jones Euro Stoxx Oil and Gas Index (August 1, 2007), for which financial market data is available for the period January, 1, 2002 until August 15, 2007 and that are located in one of the Eurozone countries.[35] The main activities of those corporations comprise crude oil and natural gas exploration and production, as well as refining and international crude oil and product trading. Some of the corporations are furthermore engaged in

[35] Those corporations are Bourbon, CGG Veritas, Eni, Fugro, Gas Natural SDG, OMV, Repsol YPF, Saipem, SBM Offshore, Technip, and Total.

services in the field of oil and gas. In this respect, we are not able to distinguish between oil and gas producers and integrated corporations. This, however, is due to the fact that many European energy corporations are integrated and, consequently, there is, e.g., no “pure” gas producer in our portfolio. The utility portfolio consists of corporations included in the Dow Jones Euro Stoxx Utilities Index (August 1, 2007), for which financial market data is available for the sample period and that are located in one of the Eurozone countries.[36] These corporations have a strong focus on electricity generation and power supply. In our empirical analysis, we make use of portfolio excess returns by subtracting the (daily) return of the one month Euro Interbank Offered Rate (Euribor) from the average stock return (log return) of the corporations considered. The arithmetic means of both portfolio excess return series do not significantly differ from zero at any conventional level (Table A. 15 in the appendix). Moreover, both series are – as expected for return series – stationary according to a Dickey-Fuller unit root test (Table A. 16 in the appendix), so that there is no danger for so-called spurious regression.[37]

The market excess return for our analysis is calculated from the Dow Jones Euro STOXX (and, consistently with the portfolio excess log returns, from the one month Euribor). It is the broadest market index of the Eurozone stock market, representing large, mid and small capitalisation companies of all Eurozone members.[38] The Dow Jones Euro STOXX has a varying number of components (September 2007: 317 corporations). In order to test whether there is an impact of oil price changes on the returns of our two portfolios, we make use of the time series of (Crude Oil) Brent (Euro per barrel) being the most relevant traded crude for European energy firms. Consistently with the existing literature, we use a variable based on the (one month) forward instead of the spot price series. The use

[36] Those corporations are AEM, EON, Endesa, Enel, Energias de Portugal, Iberdrola, Red Electrica de Espana, RWE, Snam Rete, Solarworld, Suez and Union Fenosa. Fortum Corp., Veolia Environnement and Verbund have been excluded as their business is based on renewable energy.

[37] For those as well as all other explanatory variables, a Dickey-Fuller unit root test without trend term was conducted. According to visual inspection, none of the series exhibits trends.

[38] From 2002 to 2007, these 12 members were Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, and Spain. Corporations from Slovenia, member country since January 2007, or Cyprus and Malta, members since January 2008, do not form part of the index. However, there are no corporations from these countries forming our utility and oil and gas portfolios, either.

of future or forward prices is due to the fact that they are less noisy in comparison to spot prices that are more strongly affected by very short run demand and supply fluctuations (cp. Sadorsky, 2001, Boyer and Filion, 2007). Consequently, we use the price change of the (one month) forward natural gas time series from Intercontinentalexchange (ICE, London; Euro per 100.000 British Thermal Units) as gas variable. This is the only European time series on natural gas that is available to us for the whole period 2002 to 2007 as time series from continental European energy exchanges (e.g., from the APX, Zeebrugge, or the EEX, Leipzig) are much shorter (they only start in 2005 or 2007, respectively). The disadvantage of using ICE data is that UK gas prices may be driven by fundamentals of its domestic supply and demand if the UK interconnector to Belgium is full or shut down, so that prices may temporarily decouple from continental gas prices (Kjärstad and Johnsson, 2007). Generally, UK and continental gas prices are closely related due to arbitrage possibilities, though.

As far as coal prices are concerned, we construct a coal index that is as an equal weighted portfolio of three of the most relevant global coal prices: GI Australia Freight, GI Columbia Freight, and GI South Africa Freight (all in Euro per Gigajoule). Against this background, such index should represent coal prices European corporations are facing on the world market. Our interest rate variable is constructed as the change of the so-called term premium, i.e., the difference in price changes for holding a three and a one month bill (cp., e.g., Harvey, 1989). We calculate the interest variable from three and one month Euribor, the most important interest rates from the Eurozone. Analogously to the U.S. Dollar to Canadian Dollar exchange rate in the related literature on Canadian energy stocks, we incorporate the U.S. Dollar to Euro exchange rate in our analysis. It is defined in a way that a value of 1.1 of this exchange rate implies that 1.10 Dollar is worth the same as one Euro, so that a rise of the exchange rate implies a rise of the Euro against the U.S. Dollar. Here as well, the explanatory variable is based on the price change of this exchange rate.

In order to integrate energy market volatility in our empirical approach (see preceding chapter), we use in a first step squared energy price changes. Squared price changes can be seen as good indicators of energy market volatility as they give the deviation of the changes of the respective price from its mean (which is, as very common to price data, zero for all energy price changes in our dataset, cp. Table A. 15 in the appendix). However, those volatility terms defined as the squared changes of the oil price $w_{o,t}$, of the gas price $w_{g,t}$, and of the coal price $w_{c,t}$ are positive by definition and therefore exhibit highly significant positive means in our sample (Table A. 15 in the appendix). This means, however, that these volatility variables do not indicate volatility surprises (or unexpected volatility), i.e., volatility innovation, and can, to a certain extent, be predicted. This is illustrated by the success of estimators of the ARCH-class (cp., e.g., Engle, 2001) that model volatility by dynamic processes. However, if capital markets work efficiently, only innovations, i.e., unexpected movements of selected systematic variables can affect stock returns and therefore the energy stock portfolio returns analyzed here. The use of those volatility variables that at least partly represent expected volatility could therefore introduce an errors-in-variables problem to our estimations (Chen et al., 1986).

In order to cope with this problem, we propose (additionally) using errors of AR(K) processes of squared energy price changes as volatility innovations in our estimations. This is done by estimating an AR(K) model for the squared price change series j (oil, gas, coal):

$$w_{j,t} = \theta_j + \sum_{k=1}^{K} \vartheta_{j,k} w_{j,t-k} + s_{j,t}\,, \qquad (6)$$

with $w_{j,t}$ representing the squared price change from market j at the end of period t (i.e., between t–1 and t). $s_{j,t}$ is the noise disturbance with zero mean and variance ω_j^2. θ_j and the $\vartheta_{j,k}$, besides ω_j^2 are the unknown parameters that have to be estimated by OLS. The lag lengths (K) of the respective regressions are determined according to the Bayesian Schwarz Information Criterion (BIC), and are, in or case, three for the oil volatility, and one for both the gas and the coal volatility.[39] $s_{j,t}$ is at the same time the error term of the model and therefore the volatility innovation that can be used as explanatory variable in our regression analysis. Here, it will be denoted *v* with subscripts indicating time and market. The inclusion of the $v_{j,t}$ ("generated regressors") as current levels of residuals in our two-step analysis (i.e., in the analysis of energy stock returns) should, according to Pagan (1984), yield consistent and efficient estimates.

For robustness reasons, we moreover apply a third approach in order to compute adequate volatility terms. Here, we follow the existing literature and apply an established methodology following Schwert (1989). We calculate $z_{j,t}$ as the absolute values of the error terms of an AR(*L*) model for the price changes of the series *j* (oil, gas, coal):

$$r_{j,t} = \tau_j + \sum_{l=1}^{L} \upsilon_{j,l} r_{j,t-l} + u_{j,t} \,. \tag{7}$$

Here, $u_{j,t}$ is the noise disturbance with zero mean and variance ψ_j^2. θ_j and the $\vartheta_{j,k}$, besides ψ_j^2 are the unknown parameters that have to be estimated by OLS. The lag lengths (*L*) of the respective regressions are determined according to the Bayesian Schwarz Information Criterion (BIC), and are one in all cases.[40] Based on Schwert (1989), we compute the volatilities $z_{j,t}$ as the absolute values of the error term $u_{j,t}$ of the respective model. By construction, the volatility variables $v_{j,t}$ (instead of $w_{j,t}$ and $z_{j,t}$) do not exhibit significant arithmetic means (10%-level; Table A. 15 in the appendix), indicating that $v_{j,t}$ may be a good measure of unexpected volatility as postulated by Chen et al. (1986). There is no indication for a unit root in any of these variables (Table A. 16 in the appendix).

All energy price variables (oil, gas and coal price) are furthermore graphically shown in the appendix. These are the price series of the most volatile possible

[39] Results of these regressions are available on request from the authors.
[40] Results of these regressions are available on request from the authors.

determinants of the European energy stock returns. Figure A. 1 in the appendix suggests that the oil price was constantly growing during the sample period. The same holds true for the coal price (Figure A. 3 in the appendix). The gas price, in contrast, remained relatively stable at one price level during the whole sample period, with the exception of a price explosion in late 2005 which reflects the Russo-Ukrainian gas dispute at that time (Figure A. 2 in the appendix). A look at the correlations between the variables considered in this analysis reveals that both dependent variables (the two energy portfolio excess return series) are strongly and positively related (Table A. 17 in the appendix). Amongst the explanatory variables, the market excess return correlates most strongly with both portfolio excess return series. Multicollinearity amongst the explanatory variables is no severe problem in our setting. Of course, volatilities $w_{j,t}$, $v_{j,t}$ and $z_{j,t}$ from the respective market correlate strongly.

Results

As far as the utility portfolio is concerned, the market excess return enters highly significantly into the regression equation (Table A. 18 in the appendix). The estimated parameter (beta factor) is smaller than one (0.78 for all approaches). The coefficients of the above described additional macroeconomic price change variables give mixed results: Besides the market return, both the oil price change and the coal price change show statistical significance at conventional levels. The estimated parameters for these variables have the expected signs; they are negative (-0.03) for both the oil price change, and (-0.01) for the coal price change, with the coal effect being significantly smaller than the oil effect. The estimated parameter of the third energy price variable, the gas price change, does not show significance at any conventional level. It is, against intuition, positive for all approaches, but very small (0.01). Also, none of the energy price volatility variables enters significantly into any of the regressions. This result is robust for all different specifications, i.e., for the different computations of the respective oil, gas and coal volatility variables. At least for the oil volatility variables, the (negative) signs of the estimated coefficients are as expected.

Besides, both the change of the term premium and in the U.S. Dollar to Euro exchange rate do not show significance at any conventional level. Applying the regression specification-error test (RESET) for omitted variables, we can not reject the null hypothesis of no omitted variables, indicating that our approach is well specified. Using the two standard tests on autocorrelation (Breusch-Godfrey LM test for autocorrelation and Durbin's alternative test for autocorrelation) we get (although weak) evidence for autocorrelation of first order in all regression equations. The test on autoregressive conditional heteroskedasticity (ARCH LM test) furthermore suggests highly significant ARCH effects. As far as autocorrelation is concerned, the inclusion of a lagged dependent variable to all equations does not lead to significant estimates of the autocorrelation coefficient of first order; moreover, the inclusion of the lagged dependent variable does not affect the estimation results for the other explanatory variables. Therefore, those results are not computed here[41] and we confine ourselves to base our estimations on Newey-West standard errors that are consistent in the presence of both heteroskedasticity and autocorrelation. Given the phenomenon of autoregressive conditional heteroskedasticity, we make use of a GARCH(1,1) approach for all specifications. Both variance equation coefficients (besides the constant term) differ highly significantly from zero for all specifications, underpinning the volatility dynamics present in the portfolio excess returns. The estimated coefficients from the variance equation do not suggest, as expected, an infinite conditional variance, with the sum of the two estimated GARCH coefficients being smaller than one. The GARCH mean equation confirm the OLS results of a significant effect of the market excess return, the oil and the coal price change on stock returns of Eurozone utility corporations.

For the oil and gas portfolio excess return series as well, the estimated coefficient of the market excess return enters highly significantly and with a value smaller than one (point estimates between 0.72 and 0.74) into the regression equation (Table A. 19 in the appendix). The coefficients of other macroeconomic price change variables gives positive and highly significant effects of the oil price change, the interest rate variable (term premium) and the Euro-Dollar exchange

[41] Those estimation results are available on request from the authors.

rate on the oil and gas excess portfolio returns. The estimated coefficients are not only statistically significant, but also economically, with point estimates of 0.08 to 0.10 (oil), 0.24 to 0.29 (term premium), and 0.15 to 0.21 (exchange rate). The "gas beta", in contrast, does not show statistical significance at any conventional level. The inclusion of energy market volatility variables does, in contrast to the utility portfolio case, have an impact on oil and gas portfolio excess returns: While gas volatility, as the gas price change, does not significantly enter into the regression equations, the oil volatility coefficients are negative as expected and statistically significant in all specifications. Significance is strongest (1%-level) for unexpected volatility $v_{o,t}$ as proposed as most adequate volatility indicator in the preceding subsection. The coefficients of the two additional volatility variables $w_{o,t}$ (squared oil price changes) and $v_{j,t}$ (computation based on Schwert, 1989) are statistically significant as well, but at lower levels. The comparison of estimated coefficients of these variables is difficult given the different computations of the volatility variables, but particularly $v_{o,t}$ coefficients (-0.66 to -0.81) suggest that the negative effect of oil price volatility on oil and gas stock returns is very strong also from an economic point of view.

Autocorrelation is even less of a problem in the oil and gas stock portfolio case than for the utility portfolio excess returns. Both the Breusch-Godfrey LM test and Durbin's alternative test for autocorrelation do not indicate autocorrelation of first order only in any of the approaches followed. In contrast, each regression equation exhibits highly significant autoregressive conditional heteroskedasticity (following the results of an ARCH LM test). Moreover, the RESET test indicates a misspecification of the OLS regressions, although the significance is not overwhelming. In this respect, the consideration of a time-varying volatility seems to be a possible solution to these problems. In this respect, in the GARCH(1,1) specifications, both variance equation coefficients, additionally to the constant term, differ highly significantly from zero for all specifications, underpinning the volatility dynamics present in the portfolio excess returns. As in the utility portfolio case, the estimated coefficients from the variance equation indicate a finite (mean-reverting) conditional variance.

3.2.4. Conclusions

In this chapter, we conducted a first analysis on the determinants of Eurozone energy corporations' stock returns, focussing on the relationship between energy market developments and energy stock performance. We empirically examined stocks of oil and gas business as well as of utilities, both averaged in respective portfolios. Moreover, we propose a simple approach in order to compute (energy) market volatility and apply it within our analysis. Our results suggest that stock returns of European energy corporations are not only driven by their relationship in systematic risk to the overall stock market. Energy market developments besides variation of other macroeconomic variables play an important role for Eurozone energy stocks. Particularly, we show that both oil price changes and oil price volatility affect oil and gas stocks, with oil prices being positively and oil volatility being negatively related to oil and gas stock returns. In contrast, energy stock returns do not seem to be related to gas market developments. As found in the related literature, average systematic risk of Eurozone energy corporations seems to be smaller than that one of the market. Against the empirical evidence for Canada, the return of the term spread is not negatively related with Eurozone portfolio returns. While both Sadorsky (2001) explains the negative relationship for Canadian energy corporations with high capital intensity of the industry, this does not seem to hold for its European counterpart. Still, the positive effect of the term premium we find for oil and gas corporations is in line with what has been observed for the stock markets of many OECD countries (Hjalmarsson, 2004). Moreover, an appreciation of the Euro against the U.S. Dollar, reflecting an increase in purchasing power of the European corporations on international markets, leads to positive stock market reactions for oil and gas businesses.

With respect to the relationship between, on the one hand, resource prices and their volatility, and, on the other hand, the stock market, our results show that Eurozone utilities suffer from negative stock market responses to oil price rises, while oil and gas related businesses are upvalued in such setting. The effect of oil market developments on the stock market is, in the oil and gas portfolio case, not restricted to a linear relationship between price changes at both markets: While the oil price change positively impacts oil and gas stock returns, oil volatility has a negative effect on stock returns. In this respect, our empirical analysis shows that oil and gas stocks strongly react to oil volatility particularly as measured according to the methodology proposed in this chapter. The general negative effect of energy volatility on oil and gas corporations' stocks is, however, robust to alternative constructions of the oil volatility variable.

Interestingly, and in contrast to the Canadian experience where there is a stock return sensitivity to a variation in gas prices (although smaller than to oil prices; Boyer and Filion, 2007), the gas market does not seem to play a role for Eurozone energy corporations' stocks at all. This is especially surprising in the case of electric utilities given the fact that oil, in contrast to gas, is barely used for energy generation in Europe (EIA, 2007). One reason behind this finding could be the fact that a large part of the gas sold in Europe is based on long-term contracts at a price that is determined by a formula that links gas to oil prices in order to prevent from any incentive for fuel switching (cp., e.g., Siliverstovs et al., 2004). Another explanation would be that, consistent with the findings of Haushalter (2000), energy companies hedge more strongly against gas than against oil price risks. Price changes in coal, according to EIA (2007) another important input for electricity generation in Europe, also affect stock returns of utility corporations form the Eurozone. The effect of coal price hikes that imply input cost increases for electricity generators is negative as expected. However, it is significantly smaller than the oil effect, although for European electricity generators coal, compared to oil, is by far the more widely used energy source. In this respect, this analysis suggests that stock market participants primarily use the oil price as the main indicator of resource price developments as a whole. The fact that energy (i.e., oil) market volatility affects the returns oil and gas stocks, but not of utility stocks, suggests that it is indeed commodity (oil) production reasoning according to Pindyck (2004) that entails stock market reactions. Such reasoning, suggesting that an increase in price volatility that may decrease the production of the respective commodity and possibly lead to profit reductions in the short run (and, due to the discounting of future profits also to a decrease in overall discounted future cash flows), is only relevant to oil and gas corporations, but not to utilities.

Given these findings, it is not surprising that during the last years, investments in European oil and gas stock corporations have been very profitable. Besides the generally good market situation, the rise of the Euro against the U.S. Dollar and especially the strong increase of oil prices have promoted this development. In the light of beta coefficients smaller than one as not only found in this analysis, but also in investigations for extra-European energy stocks, investments in oil and gas stocks have also been considered as relatively “conservative”. However, as suggested by the results of our empirical approach, at least European oil and gas stocks may offer a relatively weak performance in times of high oil price volatility. Whether this holds true for extra-European oil and gas stocks as well, may be one direction for future research. In any case, our result that also oil volatility that is forecastable using (relatively simple) autoregressive models indicates that, firstly, the link between energy and stock markets does not work efficiently, which may indicate that further research in this direction is needed. It secondly suggests that profits can be realized by investors making use of oil volatility forecasting models. According to our results, an investment strategy implying a short position for oil and gas stocks in times of high oil volatility expectations is profitable indeed.

As no comprehensive energy corporation-specific database for the Eurozone was available to us, we could not test whether the influence of “fundamental determinants” such as proven reserves and production volumes resembles the effects Boyer and Filion (2007) have found for the Canadian stock market. Another direction for prospective investigations in the field of energy stocks could be the integration of so-called factors (e.g., Fama and French, 1993, or Carhart, 1997) into the empirical analysis. Such factors have not been calculated for the European stock market, yet, but are easily available at least for the U.S. and have at least partly proven explanatory power for example for the American (Fama and French, 1993, 1996) and for the German stock market (Ziegler et al., 2007b). So far, it is unexplored whether such multifactor approach may help in explaining energy corporations’ stock returns.

3.3. Oil and Unemployment in Germany[42]

3.3.1. Introduction

The recent years have been marked by massive price movements on the resource markets. Particularly record high prices for oil have been reached. About twelve years after James Hamilton's (1996) prophecy of an oil shock-induced recession, indeed many observers express their fear of a new oil crisis, slowing down economic growth and causing important losses in employment. For example, in a recent speech Nobuo Tanaka, Executive Director of the International Energy Agency (IEA), argues that current oil prices were too high and would constitute a threat to economic growth (Tanaka, 2008).

For the German economy, the fear of an economic slowdown and a subsequent rise in unemployment is particularly strong. As the German unemployment rate has been rising since the 1970s until recently, unemployment has been a severe problem for the German economy even during recent economic boom phases. Reasons for this development as well as remedies to the German unemployment problem have been analyzed by numerous authors. Official statistics as well as empirical studies suggest that particularly low-skilled persons are very likely to be hit by – particularly long-term – unemployment. Against this background, training programs for low-skilled unemployed persons seems to be promising means to alleviate Germany's unemployment problem indeed (e.g., Franz, 1983, or Steiner, 2001).

This chapter also addresses unemployment in Germany, but focuses on a related question not covered to date by the scientific community. Based on time series data for Germany, we tackle the question whether oil shocks may worsen the

[42] This chapter is based on the research paper "Oil and Unemployment in Germany", co-authored by Andreas Löschel and Ulrich Oberndorfer (Correspondence is to Ulrich Oberndorfer). The paper has appeared in the Journal of Economics and Statistics (Jahrbücher für Nationalökonomie und Statistik) 229 (2009), 146-162.

German labor market situation. Such effect is not only of interest in light of recent oil price increases; indeed, a large majority of energy market experts is convinced that oil prices will continue rising also within the next years (ZEW, 2008). The German Council of Economic Experts (2006) mentions several important determinants for the gravity of oil price shocks on economic activity and the price level: the relative and absolute oil price increase given exchange rate developments and increases in the general price level, the (expected) persistence of high oil prices, the energy intensity of production and the reactions of important actors and policy areas. For many countries and world regions, resource – and particularly oil – price shocks have been shown to be economically detrimental. Hamilton (1983) for the U.S. and Papapetrou (2001) for Greece show that employment and economic activity in general is negatively affected by oil price shocks.

As far as empirical evidence for the role of the oil price for the German economy is concerned, the calculations by the German Council of Economic Experts (2006) suggest that industrial production is negatively affected by oil price shocks. In contrast, Schmidt and Zimmermann (2005, 2007) find that the macroeconomic impact of oil price shocks is limited. Schmidt and Zimmermann (2007) particularly argue that effects of recent oil price hikes may be offset by higher demand from the world market, a fact that is particularly relevant to the German economy that nowadays is much more open than in the 1970s. Another important factor driving down the impact of oil shocks is the diminishing energy intensity of German production (Schmidt and Zimmermann, 2007). However, their analysis is temporally restricted until 2002. The analyses of the German Council of Economic Experts (2006) and of Schmidt and Zimmermann (2005, 2007) do not provide evidence on the relationship between oil price shocks and (un)employment in Germany which seems particularly important in times of pronounced oil price rises for a country facing unemployment problems for several decades. Moreover, Su (2006) who develops a structural vector autoregression model for German unemployment mentions the importance of oil crises in this regard, but does not integrate an oil variable in the empirical framework.

In order to adequately address the issue of oil shock effects on unemployment in Germany, we conduct a detailed analysis with two particular features: We, firstly, tackle the question about the nature of oil price shocks since there is no consensus on the particular form of differenced oil prices to be used in an analysis of oil price impact on the macroeconomy. We make use of three different constructions of such shocks, namely a simple oil price variable according to Hamilton (1983), an oil price increase according to Mork (1989) in order to address possible asymmetric oil price effects, and the net oil price increase based on Hamilton (1996). This variable compares current oil prices with the maximum value observed during the preceding year and should therefore be a good indicator of an actual oil shock that is not representing immediate oil price corrections to earlier declines. Secondly, against the claim of a changing relationship between oil prices and the macroeconomy since the 1980s (Jones et al., 2004, and particularly for Germany Schmidt and Zimmermann, 2007), we base our analysis both on a sample period 1973 to 2008 and on a sample period for unified Germany (1990 to 2008). The remainder of this chapter is structured as follows: Section 2 highlights the background for this study. Section 3 presents the methodological approach, data and variables used as well as the results of the empirical analysis. Section 4 concludes.

3.3.2. Oil and the Labor Market: An Overview

Although different channels have been proposed to account for the relationship between oil price movements and economic activity, the most common explanation is the supply-side effect. It describes that rising oil prices indicate the reduced availability of a basic input – oil – to production (e.g., Brown and Yücel, 1999).[43] As a consequence of this scarcity, the growth of output and productivity are slowed. The decline in productivity growth dampens real wage growth, and employment.

[43] Other explanations include income transfers from the oil-importing nations to the oil-exporting nations, a real balance effect and monetary policy (Brown and Yücel, 2002).

According to Brown and Yücel (2002), such effect works as follows: If wages are nominally sticky downward, the oil price-induced reduction in GDP growth will lead to increased unemployment and a further reduction in GDP growth. This relationship holds unless unexpected inflation increases as much as GDP growth falls leading to a compensating decrease of real wages. The initial reduction in GDP growth is accompanied by a reduction in labor productivity. Unless real wages fall by as much as the reduction in labor productivity, firms will lay off workers, which will increase unemployment and cause further GDP losses.

Subsequently to the seminal paper by Hamilton (1983), a bunch of empirical papers has supported such theory-rooted negative economic effect of the oil price for the period of the 1940s until the 1970s. From more recent empirical literature, it seems, however, that the post-World War II relationship between oil prices and macroeconomic indicators such as production and employment changed – decreased – sometime in the 1980s. According to Jones et al. (2004), the meaning of this change in the oil price effect is quite important, as it can be interpreted in different ways: It is perceivable that oil prices never played such important role as suggested, e.g., by Hamilton (1983). If this would be the case, empirical research was simply not able to provide this information due to data problems, particularly due to the shortness of available time series. In contrast, a further argument states that oil prices affected the economy until the 1980s, but stopped to do so since that time.

Related to this, Brown et al. (2003) claim the predominance of oil demand rather than supply shocks in recent years. While the oil price shock in the 1970 was caused by political (supply side) reasons, recent oil price rises seem to be rather a result of economic expansion. World oil consumption is particularly boosted by the dramatic gains in oil consumption outside the OECD. The strongest gains in consumption occur in the newly industrializing Asian countries. Against this background, e.g., Lin (2008) argues that demand from China has caused the recent oil price hike. The Asian oil consumption boost, however, is accompanied by a rise in overall demand from the Far East, which itself is economically beneficial for Western European countries. Moreover, Rotemberg and Woodford (1996) relate the finding of a change in the oil price effect to their observation that sometime after 1980 OPEC lost its ability to keep the nominal price of oil relatively stable. Thereafter, variations in the demand for oil were reflected quickly in nominal price changes, and several statistical properties of oil prices changed as a result. A further argument why the oil price effect on employment has diminished over the past decades is that energy intensity practically all over the world have been declining. According to Greening et al. (1997), the decline seems to be particularly strong for Germany. This result is largely driven by shifts in the production activity mix since the 1970s. These shifts have worked towards less energy-intensive activities, explaining why the macroeconomy in Germany should theoretically be less related to oil market developments than they have been before.

Apart from the discussion of channels or transmission mechanisms of oil price shocks on the economy, previous literature has pointed out that, in order to correctly measure the effects of oil price shocks, one has to adequately address the nature of oil price shocks themselves. While Hamilton (1983) in his pioneering work established a negative economic effect of oil prices, subsequent research has argued that such linear negative relationship could only have been established against the background of the 1973 oil crisis that is included in Hamilton's (1983) data set. In this respect, Mork (1989) makes use of asymmetric oil price variables. His results suggest that the negative effect of oil price increases on the macroeconomy is not an artefact of Hamilton's (1983) data, particularly persisting in different samples. However, Mork (1989) shows that "an asymmetry in the responses is quite apparent in that the correlation with price decreases is significantly different and perhaps zero" (p. 744). There are different argumentations at hand that may explain such asymmetric effect. Hamilton (1996) notes that historical oil crises have been characterized by widespread concern about the price and availability of energy, potentially causing irreversible investment decisions to be postponed. If that indeed would be the mechanism by which oil shocks affect the economy, then a decrease in oil prices would not confer a positive effect on the economy that mirrors the negative consequences of an oil price increase. This would not imply, however, that an oil price decrease would produce an economic boom that mirrors the recession induced by an oil price increase.

In response to Hooker (1996), who demonstrated that neither the linear relation between oil prices and the macroeconomy proposed by Hamilton (1983) nor the asymmetric relation based on oil price increases alone advocated by Mork (1989) is consistent with observed economic performance during the 1990s, Hamilton (1996) proposes a further definition of an oil shock variable. As many increases in oil prices follow immediately comparable or even larger decreases, Hamilton (1996) argues that a simple asymmetric oil price variable may be a bad measure of oil price shocks. It would therefore be more appropriate to compare the current price of oil with where it has been over the previous year rather than during the previous period alone. The corresponding oil shock variable, the net oil price increase, therefore compares the price of oil in the current time period with the maximum value observed during the preceding year. If the value for the current period exceeds the previous year's maximum, the value of the variable is assigned to the change over the previous year's maximum. If the price of oil in current period is lower than it had been at any point during the previous year, the series is defined to be zero for current period. Hamilton (1996) shows that this variable outperforms other oil price measures in Granger causality tests.

3.3.3. Empirical Analysis

Methodological Approach

The empirical analysis addresses economic impacts of oil price shocks for the German macroeconomy. We apply a vector autoregression (VAR; Sims, 1980) approach using monthly data from Germany. An important choice for this type of analysis relates to the form – levels or first differences – of the variables employed. This refers to the question whether the variables employed contain one (or more) unit root(s): If the respective variables are stationary, i.e., do not contain a unit root, the VAR can be estimated in levels. If one or more variables, however, contain at least one unit root, spurious regression (Granger and Newbold, 1974) can occur, which means that the null hypothesis of no significant relationship between variables employed would be rejected in by far more cases than suggested by the respective significance levels from a t-Test. Finally, if variables containing unit roots follow a common long term relationship, i.e., are cointegrated, an estimation of an error correction model is theoretically beneficial (Engle and Granger, 1987). However, the performance of vector error correction models is contested particularly at short horizons (e.g., Naka and Tufte, 1997). Against this background, some authors from the energy economics community prefer to generally estimating VAR models in levels (for an extensive discussion cp., e.g., Farzanegan and Markwardt, 2008). In contrast, we follow Ferderer (1996) and others and estimate the VAR model using stationary transformations of those series that exhibit unit roots in order to circumvent problems related to spurious regression as well as to vector error correction models.

All in all, we estimate three different VAR specifications: One specification using a simple – linear – oil price variable according to Hamilton (1983), one using an asymmetric oil price variable according to Mork (1989), and one model consistently with Hamilton (1996) using the net oil price increase as oil shock variable. As it is common in the existing literature, the empirical approach followed in this chapter comprises different steps: We firstly apply unit root tests in order to check whether the VAR model can be estimated in levels or in first differences of the variables included. Next, we conduct Granger causality tests. Finally, we estimate VAR models and subsequently apply impulse response functions. The interpretation of this VAR approach is based on impulse response functions that give the response of one variable of the respective VAR system to an innovation to another variable of the system.

Methodological Approach

The empirical analysis conducted addresses economic impacts of oil price shocks for the German macroeconomy. We apply a VAR approach using monthly German data from for a long time series stretching from October 1973 to January 2008. Due to this long sample period, periods of oil price hikes such as in the early 1980s and, more recently, in 2006 to 2008 as well as periods of relatively stable oil prices such as in the 1990s are included. On the one hand, this seems to be very important, as a restrictive sample period selection that particularly considers only periods of oil price hikes or, respectively, of stable oil prices has been shown to drive the results of analyses of oil price shocks (e.g., Mork, 1989). On the other hand, authors such as Jones et al. (2004) and, particularly for Germany, Schmidt and Zimmermann (2007) have argued that since the 1980s, the oil price-macroeconomy relationship has changed in a way that the oil price has ceased to be decisive for the (German) economy. Hence, we additionally base or analysis on a shorter sample, namely for post-unification Germany from October 1990 to January 2008.

Our VAR approach is inspired by the recent literature on the economic impacts of oil price shocks such as Hooker (1996), Hamilton (1996), or Papapetrou (2001). We consider unemployment, the oil price, industrial production, and interest rate in our empirical approach. Data on industrial production stems from the OECD, the oil price is taken from the U.S. Energy Information Administration's (EIA) database, and data on unemployment and the interest rate stem from the time series database of Deutsche Bundesbank (German Central Bank; based on data from the German Federal Statistical Office) that is publicly available free of charge. Unemployment and industrial production data reflects the Federal Republic of Germany in a way that starting from the German unification in October 1990, data from reunified Germany (including both the former Federal Republic of Germany – West Germany – and the former German Democratic Republic – East Germany) is used. In order to control for the reunification effect, in the analysis for the whole sample period a reunification dummy taking the value of one starting from October 1990 (zero otherwise) is used. In order to control for seasonality, we use centered (orthogonalized) seasonal dummy variables at a monthly basis.

For industrial production, we use a (total industry) production index calculated to the base year 2000 (value 100). The unemployment variable gives the number of unemployed persons in West Germany (in 1000). The interest rate employed reflects money market rates in Frankfurt, the most important German banking centre. Rates for overnight money (monthly averages) are given. As far as the oil price is concerned, we opted for the Import Costs Data (in U.S. Dollar) published by the U.S. EIA. It is deflated by the consumer price index from the time series database of Deutsche Bundesbank (German Central Bank; based on data from the German Federal Statistical Office), and therefore a real oil price series. We opted for the U.S. EIA data as it is, in comparison to monthly data from comparable databases, a relatively long time series. All variables used in the empirical analysis are in logs.

As lined out in the preceding chapter, there is no consensus with respect to the oil series to be used in an analysis of oil price impact on the macroeconomy. In order to address this point which is important from a robustness point-of-view, we apply the three most common definitions of oil price series established in the literature. Besides using a simple (logged) oil series (oil; similar to Hamilton, 1983; see Figure 4 for a plot of dloil, the first differences of this series), we use an asymmetric oil price increase series based on Mork (1989, see Figure 5), defined as

$$dloilpos_t = \max\left(0, \log\left(oil_t\right) - \log\left(oil_{t-1}\right)\right). \qquad (1)$$

with oil_t representing oil import costs at time *t*. Finally, we employ the so-called net oil price increase ($nopi_t$) according to Hamilton (1996, see Figure 6), defined as

$$nopi_t = \max\left(0, \log\left(oil_t\right) - \max\left(\log\left(oil_{t-1}\right), \log\left(oil_{t-2}\right), \ldots, \log\left(oil_{t-12}\right)\right)\right). \qquad (2)$$

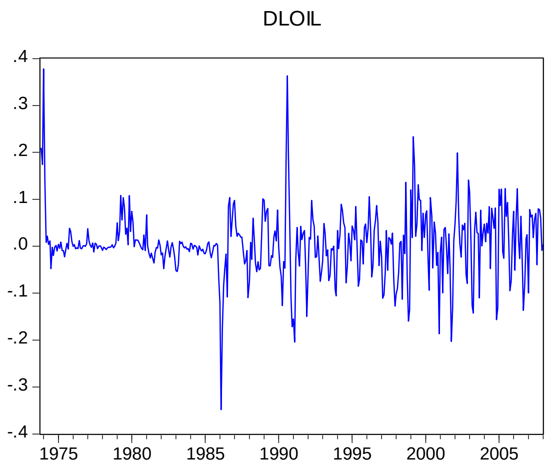

Figure 4 Real Oil Index Change (dloil; Based on Hamilton, 1983)

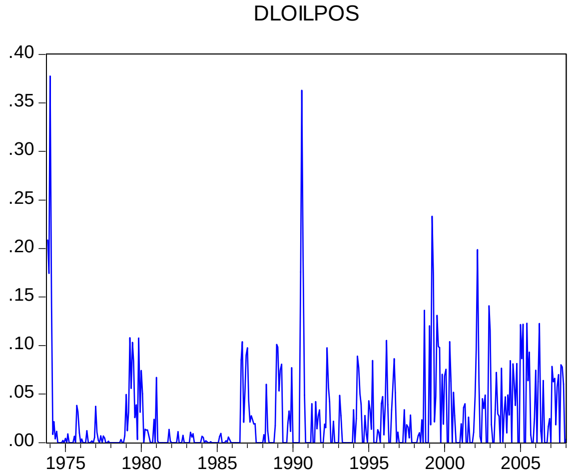

Figure 5 Oil Index Increase (dloilpos; Based on Mork, 1989)

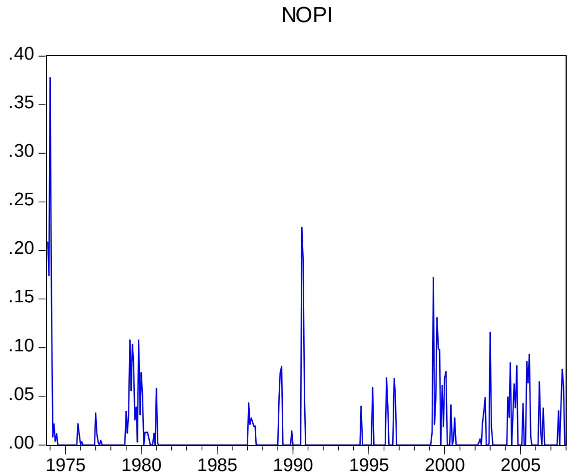

Figure 6 Real Net Oil Index Increase (nopi; Based on Hamilton, 1996)

The application of the Augmented Dickey-Fuller (ADF), Phillips-Perron (PP), and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) unit root tests (Table A. 20 in the appendix; for the 10/1990 to 01/2008 sample, see Table A. 21 in the appendix) suggest that the oil price shock variables both based on Mork (1989) and Hamilton (1996) – that are a particular form of differenced oil prices – are I(0) according to all testing procedures for both sample periods. All other variables employed – the oil price, unemployment, interest rate, production and consumer price variable – are I(1). For the oil price, all unit root tests applied indicate the existence of one unit root for both sample periods (only the ADF provides weak evidence for the oil price being I(0) for the 10/1990 to 01/2008 sample). For unemployment, evidence is compelling with respect to the existence of one unit root for the full sample. For the 10/1990 to 01/2008 sample, at least the KPSS Test indicates that the variable is I(1). The interest rate as well is I(1) according to all testing procedures. For industrial production, results are partly conflicting, but I(1) seems to be most realistic for this variable as well. Thus, these variables are differenced.

Results

Against the background of the unit root tests mentioned in the previous subsection, we firstly conduct Granger causality tests based on the three different constructions of the oil price variable. Secondly, we estimate VAR models and subsequently apply impulse response functions. Impulse response functions give the response of one variable of the respective VAR system to an innovation to another variable of the system. We compute impulse responses according to generalized impulse response functions. Unlike the orthogonalized impulse response functions obtained using the Cholesky factorization, this approach allows to compute unique impulse responses that are invariant to the ordering of variables in the VAR (Koop et al., 1996). According to existing literature using monthly data such as Papapetrou (2001), we initially estimate three versions – an 18, 12 and an 8-lag version – of each VAR model. The appropriate lag lengths of the preferred models are determined according to the results of the Akaike and Bayesian Schwarz Information Criteria (AIC/BIC). Against this background, we opt for the 18-lag models for Granger causality testing as well as for the corresponding 18-lag VAR models.

As Granger causality tests using I(1) variables may give spurious results (He and Maekawa, 2001), we conduct those tests using first differences for all I(1) variables. The respective Granger causality tests for all three different constructions of the oil price variables are given in Table 8 for the VAR specification using the oil price variable constructed according to Hamilton (1983; dloil, i.e., dlog of the oil price), in Table 9 for the VAR using the oil price variable according to Mork (1989; dloilpos, i.e., log of oil price increases), and in Table 10 for the VAR using net oil price increases according to Hamilton (1996; nopi, i.e., the log of the value for the current month exceeding the previous year's maximum, or zero otherwise).

Table 8 Granger Causality for Unemployment (dloil)

	Full sample period (10/1973-01/2008)		Sample period 10/1990-01/2008	
Dep. Var.: dl Unemployment	**Chi-Sq.**	**Prob.**	**Chi-Sq.**	**Prob.**
dloil	31.49	0.03	21.21	0.27
dl Industrial Production	53.53	0.00	52.24	0.00
dl Interest Rate	15.03	0.66	13.49	0.76
All	100.52	0.00	112.78	0.00

Note: Based on VAR estimation with 18 lags. No. obs.: 393 (full sample period); 208 (sample period 10/1990-01/2008).

Table 9 Granger Causality for Unemployment (dloilpos)

	Full sample period (10/1973-01/2008)		Sample period 10/1990-01/2008	
Dep. Var.: dl Unemployment	**Chi-Sq.**	**Prob.**	**Chi-Sq.**	**Prob.**
dloilpos	61.86	0.00	41.04	0.00
dl Industrial Production	52.83	0.00	47.84	0.00
dl Interest Rate	20.78	0.29	13.01	0.79
All	137.06	0.00	145.11	0.00

Note: Based on VAR estimation with 18 lags. No. obs.: 393 (full sample period); 208 (sample period 10/1990-01/2008).

Table 10 Granger Causality for Unemployment (nopi)

	Full sample period (10/1973-01/2008)		Sample period 10/1990-01/2008	
Dep. Var.: dl Unemployment	**Chi-Sq.**	**Prob.**	**Chi-Sq.**	**Prob.**
nopi	53.65	0.00	45.15	0.00
dl Industrial Production	44.10	0.00	46.48	0.00
dl Interest Rate	17.34	0.50	14.03	0.73
All	127.19	0.00	151.81	0.00

Note: Based on VAR estimation with 18 lags. No. obs.: 393 (full sample period); 208 (sample period 10/1990-01/2008).

According to the results of those tests, for the full sample period all oil price variables Granger cause unemployment in Germany. However, while net oil price increases according to Hamilton (1996) as well as oil price increases according to Mork (1989) Granger cause unemployment in Germany at the 1%-level, statistical significance is weaker for the simple oil price change, already indicating that variables according to Mork (1989) and Hamilton (1996) are better indicators of oil price shocks than a linear oil price series. Differences between the oil variables are even more pronounced for the post-unification sample, and follow the same logic. Here, the null hypothesis stating that the oil price variable according to Hamilton (1983) does not Granger cause unemployment in Germany cannot be rejected at any conventional level. In contrast, oil price variables according to Mork (1989) and Hamilton (1996) highly significantly Granger cause unemployment. Table 8 to Table 10 moreover indicate that industrial production, in contrast to the interest rate, is a main driver of unemployment in Germany. All other Granger causality tests are not shown in this chapter, but are available on request from the authors. The main result regarding the oil price suggest that none of the macroeconomic variables Granger causes any of the oil variables, while Mork's (1989) and Hamilton's (1996) oil variables – in contrast to the linear one – Granger cause the interest rate variable.

The results from Granger causality tests are underpinned by the VAR analysis itself. Here, we use, where necessary, stationary transformations of the respective variables as for the Granger causality tests (see Data and Variables as well as the unit root tests in Table A. 20 and Table A. 21 in the appendix). Impulse response functions (IRFs) according to generalized IRF approach give the response of one variable of the respective VAR system to a generalized one standard deviation innovation to another variable of the system. IRFs for all variables are reported in rates. Multiplying these values by 100 gives percentage values. Bands around the impulse responses give the 95% confidence interval, indicating a statistically significant effect only in case when both bands give either positive or negative values, respectively. This analysis focuses on the effects of an innovation from the oil variables, and particularly on the responses of the unemployment variable. Impulse response functions for other variables are not shown in this chapter, but are available on request from the authors.

For the full sample period, the impulse response functions based on all three VAR specifications (according to the three different definitions of the oil variable) have roughly the same shape. However, the impact on unemployment for the simple oil variable according to Hamilton (1983; Figure 4) is relatively weak statistically not significant based on the 95% confidence interval. For the oil price increase according to Mork (1989; Figure 8) and particularly for the net oil price increase as introduced by Hamilton (1996), the unemployment response is stronger and statistically significant (cp. Figure 9). For all three specifications, the oil effect has its climax about three months subsequently to the oil shock, and dies out rather quickly.

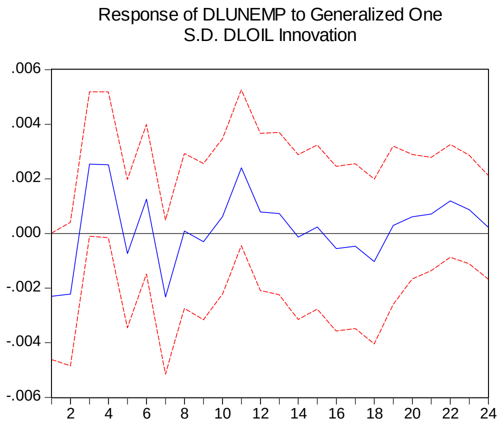

Figure 7 Unemployment Response to Oil Price Innovation (Full Sample Period)

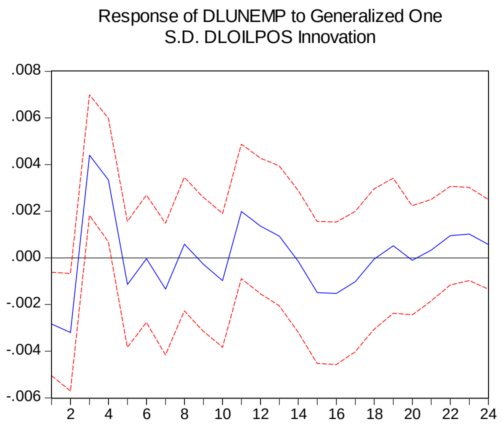

Figure 8 Unemployment Response to Oil Price Increase Innovation (Full Sample Period)

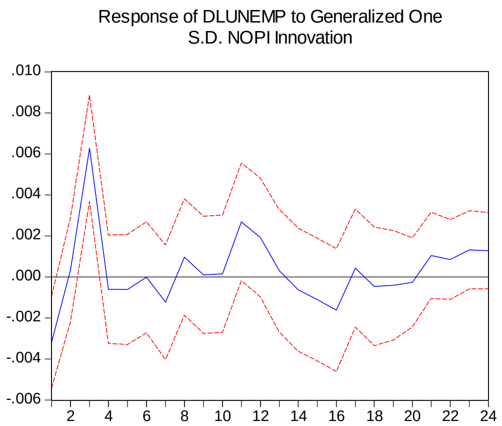

Figure 9 Unemployment Response to Net Oil Price Increase Innovation (Full Sample Period)

Against the claims of a decreased importance of the oil price for the German (macro)economy in recent years, impulse response functions for our VAR models indicate that the effect of oil shocks on unemployment in Germany have not vanished by far. For the post-unification sample period (10/1990-01/2008), the impulse responses based on all three VAR specifications are comparable to those calculated for the full sample period. Here as well, the impact on unemployment for the simple oil variable according to Hamilton (1983; Figure 10) is weaker - from both an economic and a statistical perspective – than for the oil price increase according to Mork (1989; Figure 11) and particularly for the net oil price increase as introduced by Hamilton (1996; cp. Figure 12). The shape of all three impulse responses (referring to the three different VAR specifications) is relatively similar to those calculated from the full sample period VARs, with two oil effect hikes about three months as well as eleven months subsequently to the oil shock.

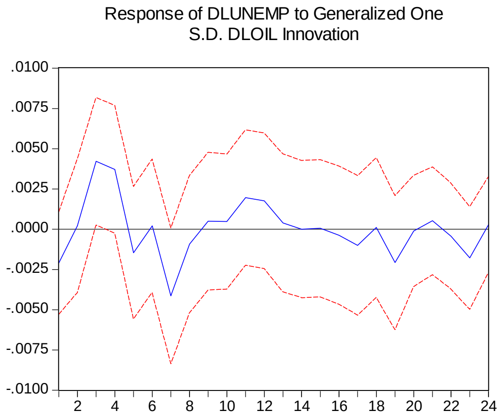

Figure 10 Unemployment Response to Oil Price Innovation (10/1990-01/2008)

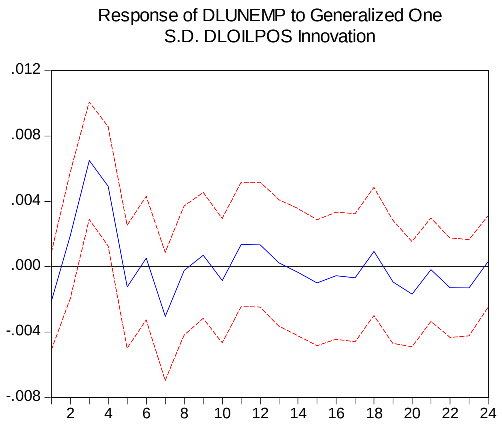

Figure 11 Unemployment Response to Oil Price Increase Innovation (10/1990-01/2008)

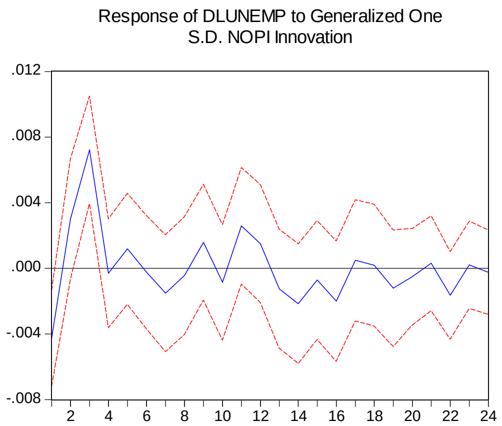

Figure 12 Unemployment Response to Net Oil Price Increase Innovation (10/1990-01/2008)

The results from the impulse responses, together with Granger causality tests, indicate that there is indeed a negative oil shock effect on the German labor market. Particularly, this effect seems to be rather constant over the last decades: There is no indication that in recent years, oil shocks affect unemployment in Germany in a different way than they have done since the 1970s. The only market difference between the two samples considered here is that, econometrically speaking, it is more difficult to capture what is an oil shock in the post 1990 data than before. However, not only according to Hamilton’s (1996) net oil price increase, but also to Mork’s (1989) oil price increase, a hike of unemployment as a response to an oil shock is predicted by this empirical investigation.

3.3.4. Conclusions

The recent years have been marked by massive price movements on the resource markets. Particularly record high prices for oil have been reached. Against this background, the current chapter addresses possible oil price impacts on unemployment for Germany. Firstly, we survey theoretical and empirical literature on the oil-unemployment relationship and relate them to the German case. Secondly, we illustrate this issue within the framework of a vector autoregression (VAR) approach for Germany. For this purpose, we use three different specifications in order to adequately address the uncertainty related to the construction of an adequate oil shock variable. Using monthly data from 1973 to 2008, we show that the oil price – in all three specifications – increase unemployment on the German labor market. For a restricted sample period for post-unification Germany, we oppose claims that the oil to macroeconomy relationship has weakened since the 1980s. We find, however, that the relationship between the oil price and unemployment is more difficult to show for this sample: Here, the change in the oil price as a simple oil price variable does not Granger cause variations in German unemployment. In contrast, our results suggest that oil price increases according to Mork (1989) or oil shocks according to Hamilton’s (1996) net oil price increase highly significantly affect unemployment in post-unification Germany. This result is confirmed by impulse response functions that show a significant unemployment response about three months subsequently to a respective oil price shock. The IRFs also suggest that the magnitude of oil shock effects on unemployment in Germany has not diminished in the last decades.

These results show that, although the German economy has become much more energy-efficient in recent years, its macroeconomy and particularly labor market situation is still very much dependent on the situation on the oil market. Developments on the oil market are crucial from an economic point of view. They, however, seem to be better indicated by (net) oil price increases than by a linear oil price variable. This may be due to the costly resource reallocation in situations of actual oil price *shocks* (Jones et al., 2004). The result suggests that indeed, as Hamilton (1996) argues, it is a rather general concern about the price and availability of energy instead of fully rational reasoning that results in negative consequences of an oil price increase. This may indicate that the German energy efficiency improvements realized in the past 20 years did not have drastic (alleviating) impacts on the oil-macroeconomy relationship.

Given these results, it seems possible that the importance of energy prices for the macroeconomy has simply been underestimated in recent years. Besides the fact that developments on the energy markets have made it more difficult to compute adequate oil price shock measures, also the relatively uneventful energy market situation with, particularly in the 1980s and 1990s, only modest net oil price increases (see Figure 6) may have contributed to such assessment of the oil-macroeconomy relationship. In this sense and against the background of the oil price boom until mid-2008, our results seem to suggest upcoming increases in the German unemployment. In the light of long-term scenarios of further increasing oil prices, the results moreover suggest that future developments on the oil market may constitute a heavy burden on the German labor market. Future research may particularly tackle the question about how economic and energy policy can effectively fight this unpleasant oil to labor market relationship.

4. Conclusion

The aim of this thesis is to analyze the relationship between environmental regulation as well as energy market developments on the one hand, and economic performance on the other. Energy prices undisputedly represent costs for energy using firms. Due to its economic effects, moreover, environmental regulation is widely and controversially discussed (see, e.g., the discussion in Jaffe et al., 1995). As suggested by both empirics and microeconomic theory, compliance with stringent environmental regulation is commonly associated with a significant burden for polluting firms or sectors and, as a consequence, with reduced profitability. However, for the particular case of an emission trading scheme with free allocation of emission rights (grandfathering) – a case that is comparable to the first phase of the EU ETS – economic theory suggests that covered firms can realize additional producer rents in the scheme if they are able to pass on carbon costs to their consumers (Sijm et al., 2006). Apart from that, the controversial Porter hypothesis questions the negative economic consequences of environmental policy, suggesting that stringent environmental regulation provides incentives for companies to innovate and that these innovations can stimulate economic growth and competitiveness of the regulated country (Porter and van der Linde, 1995).

Concerns that energy price hikes would slow down economic growth, leading to increased unemployment and reduced profits, have been expressed since the 1970s, but particularly in recent years (Tanaka, 2008). However, this does not mean that all economies face the same threats in times of energy crises, neither do all of their sectors (Jones et al., 2004). At the national level, highly energy-efficient economies such as Germany are assumed to be only moderately affected by energy price booms (Schmidt and Zimmermann, 2007). From a sectoral perspective, the energy industry is even claimed gaining from energy price booms: Such price hikes imply that the output prices of this industry rise while demand elasticities of energy use are relatively low (Boyer and Filion, 2007). Energy intensive industries, in contrast, face a major input cost shock in times of energy crises.

Generally, not only energy prices as such, but also price volatility shocks are highly relevant from an economic point of view (Ferderer, 1996, Sadorsky, 1999). Many authors such as Sauter and Awerbuch (2003) even argue that since "the 1980s, oil price volatility is more significant in its effects on economic activity than the oil price level". The economic rationale for this paramount importance of volatility is the fact that it represents risk and uncertainty inherent in the respective market. However, energy price volatility is omitted in most of the previous analyses.

In this thesis, the relationship between environmental regulation and economic performance is tackled from different perspectives. Within the framework of a political-economy analysis of allowance allocation in the EU Emission Trading Scheme, it is shown in chapter 2.1. of this thesis that economic strength can, via lobby power, lead to a comparably low regulatory burden of any sector. A common-agency model predicts the implementation of inefficiently high allowance allocation, thereby shifting the regulatory burden to those sectors excluded from the scheme. Moreover, lobbying for allowances affects the distribution of permits within the scheme in favor of large emitters. An empirical analysis corroborates these predictions for a large cross-section of German firms: Emitters represented by powerful interest groups were allocated more generously, if they were heavily exposed to regulation at the same time. Furthermore, lobbying induces a deviation of EU allowance allocation from its economically efficient level.

Complementary to the political-economy analysis, chapter 2.2. tackles the question about the role of the EU Emission Trading Scheme for firm performance and employment. It provides an overview of relative allowance allocation within the EU ETS as well as an empirical analysis for a large sample of German firms covered by the scheme. Econometric techniques are employed in order to assess the impacts of EU emission regulation on both firm revenues and employment. The dataset indicates that the EU ETS was in an overall long position in 2005, although allowance allocation was very heterogeneous across Member States. The econometric analysis suggests that within the first phase of the EU ETS, relative allowance allocation did not have a significant impact on firm performance and employment of regulated German firms.

Chapter 2.3. addresses economic impacts of environmental action that is not necessarily motivated by environmental regulation itself. A production function approach accounting for environmental investment as well as environmental and energy expenditures as capital inputs provides the basis for this inquiry. An empirical analysis making use of a panel dataset of the German manufacturing industry between 1996 and 2002 is also provided. The estimations show only weak evidence for a significant contribution of both environmental and energy expenditures to production growth. In contrast, environmental investment has a positive impact on production growth, indicating that environmental performance, as measured by environmental investment, may be a productivity driver. These results moreover suggest that, in order to be compatible with economic goals such as productivity, environmental regulation should stimulate investment.

This thesis contains different approaches in measuring economic effects of energy market developments on economic performance. Linking the topics of energy markets and environmental regulation, a first assessment provided in chapter 3.1. relates to the economic effects of EU carbon market developments. Here, EU Emission Allowance price effects on stock prices of electricity corporations as an indicator of their expected future cash flows and therefore of their economic performance are analyzed. The results suggest that EU Emission Allowance price developments matter to the stock performance of European electricity firms: EUA price changes and stock returns of these corporations are shown to be positively related. This suggests that electric utilities can profit from high EUA prices. This effect should be rooted in long positions of EU Emission Allowances and particularly in strong ability to pass through carbon costs of these firms. The effect does not work asymmetrically, so that stock markets do not seem to react differently to EUA appreciations in comparison to depreciations. The carbon market effect is shown to be both time- and country-specific: It is particularly strong for the period of EUA market shock in early 2006, and differs with respect to the national electricity market in which the respective electricity corporations operate. Stock market reactions to EUA volatility can not be shown.

In chapter 3.2., an assessment of the relationship between energy market developments and the performance of European energy stocks is conducted. As the literature on stock market performance of energy corporations is limited to the analysis of energy prices, the role of energy market volatility effects for the stock market is assessed in particular. Moreover, in order to avoid errors-in-variables problems due to the inclusion of systematic (forecastable) volatility variables, a simple methodology to compute unexpected energy volatility is developed and applied in the empirical analysis. The analysis shows that oil price hikes have a negative impact on stock returns of European utilities. In contrast, they lead to an appreciation of oil and gas companies. Interestingly, forecastable oil market volatility negatively affects European oil and gas stocks. On the one hand, this suggests that European oil and gas corporations are vulnerable to oil volatility shocks. On the other hand, this effect implies profit opportunities for strategic investors. The gas market does not play a role for the pricing of Eurozone energy stocks, while coal price developments affect the stock returns of European utilities. However, this effect is small compared to oil price impacts, although oil is barely used for electricity generation in Europe. In this light, the results of this analysis suggest that for the European stock market, the oil price is the main indicator of resource price developments as a whole.

In chapter 3.3., the macroeconomic impacts of oil price developments are assessed. For the German economy, the fear of an oil price induced economic slowdown and a subsequent rise in unemployment is particularly strong. As the German unemployment rate has been rising since the 1970s until recently, unemployment has been a severe problem for the German economy even during recent economic boom phases. In this light, unemployment in Germany as an important outcome variable of the economic performance of German firms and sectors is analyzed with a focus on oil market impacts. A vector autoregression (VAR) approach using monthly data provides evidence for the oil to macroeconomy relationship in Germany since 1973. Against the background of uncertainty related to the construction of an adequate oil variable, three different specifications based on different oil shock computations are provided. Using monthly data from 1973 to 2008, the analysis shows that oil price shocks increase unemployment in the German labor market. Moreover, an assessment of a restricted sample period for post-unification Germany questions that the oil to macroeconomy relationship has weakened since the 1980s. Apart from that, the results suggest that for empirical research in this field, the construction and use of adequate oil shock variables has become crucial.

All in all, this thesis contributes to the existing literature on the relationship between environmental regulation and energy market developments on the one hand, and economic performance on the other. Although not providing evidence for the controversial Porter hypothesis, the thesis shows that the economic impacts of the recent EU environmental policy which is aimed at combating man-made climate change have been modest at most. Consistent with economic theory reasoning, the low stringency of recently adopted regulatory measures is identified as one important driver of this result. Moreover, results presented in this thesis also indicate the importance of political economy mechanisms for the design of EU ETS and of environmental regulation in general. These mechanisms are shown to be a driver of the low stringency and, consequently, of the small economic effects during the first phase of EU ETS. Besides, the thesis highlights the role of investment stimulation if the goal of environmental regulation is not only the protection of the environment, but also the compatibility with economic goals such as productivity.

Furthermore, this thesis provides new insights into the role of energy market developments for the economic performance of firms and sectors. In this respect, a first analysis of the stock market effects of the EU Emission Allowance market shows the relevance of the EU ETS to the financial market performance of European electricity generators. Besides, this thesis demonstrates, in particular, the paramount importance of oil market developments for the economy as a whole. The thesis suggests that amongst all natural resources, oil is the most relevant one to Eurozone energy corporations, strongly affecting its stock prices.

It is also shown that besides oil prices, oil volatility plays an important role to stock market development. Finally, the thesis highlights the relevance of oil market developments for the overall economy, in showing that unemployment in Germany is strongly affected by oil price shocks. Apart from indicating the importance of constructing adequate oil shock variables for providing robust evidence in this field, the thesis particularly opposes claims that the German oil to macroeconomy relationship has weakened since the 1980s. This suggests that an emerging oil crisis would have serious effects on the German economy, implying a significant increase in unemployment.

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Appendix

Appendix Chapter 2.1.

Theoretical Framework: Firm Behavior

Profit maximization in sector *ets* yields the following first-order conditions for firms in the *ets* sector:

$$0=\frac{\partial \pi_{ets}}{\partial q_{ets}}= p_{ets}-c_{ets}(\mu_{ets})-\sigma(1-\alpha)\mu_{ets} \;\Leftrightarrow\; p_{ets}=c_{ets}(\mu_{ets})+\sigma(1-\alpha)\mu_{ets} \qquad (13)$$

$$0=\frac{\partial \pi_{ets}}{\partial \mu_{ets}}=-c_{ets}'(\mu_{ets})q_{ets}-\sigma(1-\alpha)q_{ets} \;\Leftrightarrow\; -c_{ets}'(\mu_{ets})=\sigma(1-\alpha)\,. \qquad (14)$$

While condition (13) states that given the firm's behavior the marginal benefit of sectoral production equals its social cost, condition (14) implies that the marginal cost of emission abatement equals the permit price adjusted by the marginal cost or benefit from allowance allocation. Moreover, differentiation of the profit function w.r.t. α implies that $K_{ets}'(\alpha)=\sigma\mu_{ets}q_{ets}>0$, i.e., political contributions increase in the allocation factor (as do sectoral profits).

Profit maximization in sector *nets* yields the following first-order conditions:

$$0=\frac{\partial \pi_{nets}}{\partial q_{nets}}= p_{nets}-c_{nets}(\mu_{nets})-\tau\mu_{nets} \;\Leftrightarrow\; p_{nets}=c_{nets}(\mu_{nets})+\tau\mu_{nets} \qquad (15)$$

$$0=\frac{\partial \pi_{nets}}{\partial \mu_{nets}}=-c_{nets}'(\mu_{nets})q_{nets}-\sigma q_{nets} \;\Leftrightarrow\; -c_{nets}'(\mu_{nets})=\tau\,. \qquad (16)$$

Analogously to the first-order conditions in the *ets* sector, condition (15) states that the marginal benefit of *nets* production equals its social cost, while condition (16) implies that the marginal cost of emission abatement equals the value of the emission tax.

Empirical Analysis: The CREDITREFORM Database

The CREDITREFORM database is a financial and economic database that includes information of sales and employment of German firms. It is the most comprehensive database on German firms, containing a random sample of 20.000 solvent and 1.000 insolvent firms in Germany. From the CREDITREFORM database, we use levels and differences from firm revenue and employment data between 2002 and 2005. Those data have been matched with the allocation factor (allowances allocated divided by verified emissions) from the EU Independent Community Transaction Log. This has been conducted by supplementing allocation data that has been aggregated at the firm level with CREDITREFORM data. The main criteria for this database matching were the respective company names and addresses. The matching results have been carefully checked for consistency reasons. Sectoral dummy variables have been constructed as follows: electricity: NACE code between 4000 and 4020; other energy: NACE code between 4020 and 4500; manufacturing: NACE code between 2600 and 3700.

List of Tables

Table A. 1 Descriptive Statistics

	Obs.	Mean	Std. Dev.	Min.	*Max.*
Allowances Allocated	175	533645.90	2808694	272	3.46e+07
Deviation from Efficient Allocation	175	71313.05	244591.7	-8542.70	1687941
Verified Emissions (t CO_2)	175	511996.50	2907576.00	50	3.65e+07
Squared V. Emissions	175	8.67e+12	1.01e+14	2500	1.33e+15
Lobby (no. of representatives)	175	108.39	74.77	7	350
Lobby x Emissions	175	6.48e+07	4.50e+08	8000	5.84e+09
Lobby x Employment 2004	175	114553.80	282992	14	2370760
Employment 2004	175	1279.56	3422.74	1	33810
Employment 2002	175	1351.07	3875.96	1	33049
Employment 2001	155	1088.37	3191.49	1	37707
Employment 2000	144	1370.72	4645.31	1	42317
Employment 2002 squared	175	1.68e+07	1.16e+08	1	1.09e+09
Employment 2001 squared	155	1.13e+07	1.14e+08	1	1.42e+09
Employment 2000 squared	144	2.33e+07	1.82e+08	1	1.79e+09

Table A. 2 Correlation Matrix of Selected Regression Variables

	Allowances Allocated	Verified Emissions	Squared V. Emissions	Employ-ment	Lobby	Lobby x Emissions	***Lobby x Employ-ment***
Allow. Allocated	1.0000						
Verified Emissions	0.9988	1.0000					
Squared V. Emissions	0.9792	0.9870	1.0000				
Employ-ment 2004	0.0631	0.0648	0.0667	1.0000			
Lobby	0.0858	0.0799	0.0591	-0.0790	1.0000		
Lobby x Emissions	0.9985	0.9996	0.9872	0.0608	0.0892	1.0000	
Lobby x Employ-ment 2004	0.7180	0.1531	0.1519	0.8775	0.2450	0.1531	1.0000

Note: 131 observations. Pearson's correlation coefficient for the respective variable pairs is given.

Table A. 3 Specification Tests for First Stage Regressions

	Verified Emissions	**Squared V. Emissions**	**Lobby x Emissions**
F-Test first stage regression specification (1)	0.00***	-	-
F-Test first stage regression specification (2)	0.00***	0.00***	0.00***

Note: 131 observations. F-Test (p-value) on null hypothesis of joint insignificance of all explanatory variables.*, **, and *** indicate significance at the 10%-, 5%-, and 1%-level, respectively. The full results from these first stage regressions are available on request from the authors.

Table A. 4 German Manufacturing Sectors and Respective Industrial Associations

Sector No.	Name of sector	Industrial associations
1	Agricultural products	German Farmers Association (DBV)
2	Forestry & fishery products	German Forestry Council (DFWR) German Fishery Association (DFV)
3	Electric power & steam & warm water	German Electricity Association (VDEW)
4	Gas	Association of the German Gas and Water Industries (BGW)
5	Water (distribution)	Association of the German Gas and Water Industries (BGW)
6	Coal & coal products	German Mining Association (WVB) German Hard Coal Association (GVST) German Lignite Industry Association (DEBRIV)
7	Minery products (without coal & gas & petroleum)	German Mining Association (WVB)
8	Crude oil & natural gas	Association of the German Oil and Gas Producers (WEG)
9	Chemical products & nuclear fuels	Association of the German Chemical Industry (VCI)
10	Oil products	Association of the German Petroleum Industry (MWV)
11	Plastics	Association of the German Plastics Processing Industry (GKV) Federation of German Woodworking and Furniture Industries (HDH) Federation of German Paper, Cardboard and Plastics Processing Ind. (HPV)
12	Rubber	German Rubber Manufacturers' Association (WDK)
13	Stone & lime & cement	German Building Materials Association (BBS)
14	Ceramic	German Federation of Fine Ceramic Industry (AKI)
15	Glass	German Glass Industry Federation (BV Glas)
16	Iron & steel	German Steel Federation (WV Stahl) German Federation of Steel and Metal Processing (WSM)
17	Non-ferrous metals	Federation of the German Non-Ferrous Metals Industry (WVM) Federation of German Steel and Metal Processing (WSM)
18	Casting products	German Foundry Association (DGV)
19	Rolling products	Association of German Drawing Mills (STV) Association of German Cold Rolling Mills (FVK)
20	Production of steel etc	German Structural Steel and Power Engineering Association (SET)

Table A. 4 (Continued): German Manufacturing Sectors and Respective Industrial Associations

Sector No.	Name of sector	Industrial associations
21	Mechanical engineering	Federation of the German Engineering Industry (VDMA)
22	Office machines	–
23	Motor vehicles	Association of the German Automotive Industry (VDA)
24	Shipbuilding	German Shipbuilding and Ocean Industries Association (VSM)
25	Aerospace equipment	German Aerospace Industries Association (BDLI)
26	Electrical engineering	German Electrical and Electronic Manufacturers’ Association (ZVEI)
27	Engineers' small tools	German Industrial Association for Optical, Medical and Mechatronical Technologies (SPECTARIS) Federation of German Jewellery, Watches, Clocks, Silverware and Related Industries
28	Metal and steel goods	–
29	Music instruments & toys etc.	National Association of German Musical Instruments Manufacturers (BDMH) German Association of the Toy Industry (DVSI)
30	Timber	Federation of German Woodworking and Furniture Industries (HDH) Association of the German Sawmill and Wood Industry (VDS)
31	Furniture	Federation of German Woodworking and Furniture Industries (HDH)
32	Paper & pulp & board	German Pulp and Paper Association (VDP)
33	Paper & board products	German Pulp and Paper Association (VDP) Federation of German Paper, Cardboard and Plastics Processing Industry (HPV)
34	Printing and publishing	German Printing Industry Federation (BVDM)
35	Leathers & footwear	German Leather Federation (VDL) Federation of the German Shoe Industry (HDS)
36	Textiles	Federation of German Textile and Fashion Industry
37	Clothing	Federation of the German Clothing Industry (BBI)
38	Food products	Federation of the German Food and Drink Industries (BVE)
39	Beverages	Federation of the German Food and Drink Industries (BVE)
40	Tobacco products	Federation of the German Cigarette Industry (VdC)
41	Building & construction	German Construction Industry Federation (HDB)
42	Recovery & repair	German Construction Industry Federation (HDB)

Appendix Chapter 2.2.

Data on EU ETS Allocation

Our analysis is based on data on approximately 12.000 installations being covered by the EU ETS legislation. Each installation has an Operator Holding Account in its national registry to which the allowances are submitted, and each Member State of the European Union has an obligation to interlink the national registry with the EU-wide databank Community Transaction Log. The Community Transaction Log's web pages contains information on allowances that have been allocated in accordance with the final National Allocation Plans, verified emissions, surrendered allowances and compliance status for all installations in Member States with registries. We assessed the emission data from the Community Transaction Log in two steps:

- Data extraction from the Community Transaction Log and data processing, and
- Aggregation of installation-level data on the sectoral and national level.

The AMADEUS Database

Besides the emission data from the Community transaction log, economic data is of great importance for assessing the competitiveness effects of the EU ETS. AMADEUS (Analyse Major Databases from European Sources) is a comprehensive, pan-European database containing economic and financial information on 9 million public and private companies. AMADEUS combines data from over 30 specialist sources and provides data in a comparable format. It is created and produced by Bureau van Dijk. In this analysis, sectoral information for our German firm sample is based on the four digit NACE (industry) codes of the firms provided by AMADEUS. According to this, we have created several indicator variables that are given the value 1 for a company that forms part of the respective industry, and 0 otherwise. The indicator variables are “electricity” (13 per cent of the sample firms; NACE code between 4000 and 4020, “production and distribution of electricity”), “energy” (7 per cent of the sample firms; NACE code between 4020 and 4500, “manufacture of gas; distribution of gaseous fuels through mains", "steam and hot water supply", "collection, purification and distribution of water"), "pulp & paper" (10 per cent of the sample firms; NACE code between 2100 and 2200, industry subsection "manufacture of pulp, paper, and paper products"), "mining" (10 per cent of the sample firms; NACE code between 1000 and 1500, industry subsection "mining and quarrying"), "coke & petroleum" (2 per cent of the sample firms; NACE code between 2300 and 2400, "manufacture of coke, refined petroleum products and nuclear fuel"), "other manufacturing" (24 per cent of the sample firms; NACE code between 2600 and 3700, manufacture of non-metallic mineral products, basic metals and fabricated metal products, machinery and equipment, electrical and optical equipment, transport equipment, other manufacturing), and "business" (5 per cent of the sample firms; NACE code between 7000 and 7500, section "real estate, renting, and business activities").

The CREDITREFORM Database

This database is a financial and economic database that includes information of sales and employment of German firms. It is the most comprehensive database on German firms, containing a random sample of 20.000 solvent and 1.000 insolvent firms in Germany.. Given a consistent form identification number, it is coherent with the AMADEUS database. From the CREDITREFORM database, we use levels and differences from firm revenue and employment data between 2002 and 2005, from AMADEUS, we use generated sectoral indicator variables (see above). Those data have been matched with the allocation factor (allowances allocated divided by verified emissions) from the Community Transaction Log. This has been conducted by supplementing allocation data that has been aggregated at the firm level with AMADEUS and CREDITREFORM data. The main criteria for this database matching were the respective company names and addresses. The matching results have been carefully checked for consistency reasons.

Table A. 5 Sectoral Distribution of Sample Firms

Sector	*Frequency: No. sample firms (%)*
Mining	9 (2%)
Electricity	55 (13%)
Energy	29 (7%)
Business	20 (5%)
Pulp & Paper	43 (10%)
Coke & Petroleum	8 (2%)
Other Manufacturing	102 (24%)
Other	153 (37%)
Total	419 (100%)

Table A. 6 Correlation Analysis for German Firm Sample

	Allocation Factor	Revenues 2005-2004	Revenues 2004-2003	Revenues 2005	No. Employees 2005-2004	No. Employees 2004-2003	No. Employees 2005	Mining	Electricity	Energy	Business	Pulp & Paper	Coke & Petroleum	***Other Manufacturing***
Allocation Factor	1.00													
Revenues 2005-2004	0.01	1.00												
Revenues 2004-2003	-0.03	-0.36	1.00											
Revenues 2005	-0.02	-0.52	0.57	1.00										
No. Employees 2005-04	0.03	-0.22	-0.03	0.89	1.00									
No. Employees 2004-03	-0.02	0.06	0.43	0.35	0.19	1.00								
No. Employees 2005	-0.01	-0.90	0.56	0.79	0.02	0.02	1.00							
Mining	0.03	0.02	0.01	0.04	0.03	0.03	-0.02	1.00						
Electricity	0.17	0.02	-0.06	-0.06	0.03	0.03	-0.04	-0.13	1.00					
Energy	0.02	0.01	-0.04	-0.04	0.02	0.02	-0.03	-0.09	-0.11	1.00				
Business	-0.03	-0.03	-0.03	-0.04	0.01	0.01	-0.02	-0.07	-0.09	-0.06	1.00			
Pulp & Paper	-0.05	0.01	-0.04	-0.06	0.03	-0.03	-0.04	-0.05	-0.13	-0.09	-0.08	1.00		
Coke & Petroleum	-0.04	-0.01	-0.02	-0.01	0.01	-0.01	-0.02	-0.02	-0.05	-0.04	-0.03	-0.05	1.00	
Other Manufacturing	-0.04	0.04	-0.04	-0.05	0.03	-0.05	-0.04	-0.08	-0.22	-0.15	-0.12	-0.19	-0.08	1.00

Note: 419 observations. Pearson's correlation coefficients for the respective variable pairs are given. Lagged levels and differences of higher order for the revenue- and employment variable are omitted for brevity.

Table A. 7 Regression Results on 2005 Revenue Development for German Firm Sample

	(1) OLS	**(2) OLS**	**(3) 2SLS**	**(4) 2SLS**	**(5) IRLS**	*(6) IRLS*
Allocation Factor	122.14 (110.72)	83.72 (117.58)	50538.58 (42836.84)	1552.76 (2140.87)	-0.33 (0.75)	-0.36 (0.76)
Revenues 2004-2003 (Mio. Euro)	-0.03 (0.66)	-	0.01 (1.25)	-	0.22*** (0.00)	0.21*** (0.00)
Revenues 2003-2002 (Mio. Euro)	0.01 (0.18)	-	-0.30 (0.84)	-	-0.02*** (0.00)	-0.02*** (0.00)
Revenues 2003 (Mio. Euro)	-0.05 (0.18)	-	1.24 (1.72)	-	0.03*** (0.00)	0.03*** (0.00)
No. Employees 2003	-0.18*** (0.07)	-0.19*** (0.03)	-0.66 (0.64)	-0.19*** (0.03)	0.00*** (0.00)	-
No. Employees 2004-2003	0.15 (0.11)	-	0.34** (0.14)	-	0.00*** (0.00)	-
Mining	-225.89 (255.96)	-	338.81 (6456.00)	-	6.21** (2.99)	5.58* (2.95)
Electricity	-483.89*** (134.43)	-471.20*** (112.97)	-8980.94 (11737.64)	-	7.61*** (1.39)	7.07*** (1.30)
Energy	-491.44*** (128.93)	-488.11*** (105.70)	-3335.58 (5964.47)	-443.98** (212.50)	4.92*** (1.76)	4.17** (1.70)
Business	-1083.73** (529.95)	-1085.56* (598.66)	5823.88 (6566.77)	-	1.28 (2.08)	-
Pulp & Paper	-482.81*** (116.57)	-478.65*** (100.03)	2020.76 (3730.35)	-293.81* (155.56)	0.39 (1.51)	-
Coke & Petroleum	-836.93* (479.15)	-878.94* (469.98)	5482.63 (7324.90)	-	7.61** (3.15)	8.07*** (3.15)
Other Manufacturing	-181.27 (192.49)	-	423.98 (3146.08)	-	1.38 (1.12)	-
Constant Term	436.91*** (152.38)	475.14*** (164.28)	-61101.61 (51916.09)	-1431.85 (2611.28)	-3.17*** (1.18)	-2.44** (1.05)
No. Obs.	419	419	419	419	413	414
R-squared	0.84	0.80	0.84	0.82	-	-
F-Test (p-Val.)	0.00	0.00	0.00	0.00	0.00	0.00
F-Test on excl. exp. var. (p-Val.)	-	0.50	-	0.29	-	0.00

Note: Dep. var.: Revenues 2005-2004 (Mio. Euro). Std. errors in brackets (OLS, 2SLS: White robust std. errors). *, ** and *** show significance at the 10%-, 5%-, and 1%-level, respectively.

Table A. 8 Regression Results on 2005 Employment Development for German Firm Sample

	(7) OLS	(8) OLS	(9) 2SLS	(10) 2SLS	(11) IRLS	(12) IRLS
Allocation Factor	30.23 (119.04)	-12.00 (62.79)	-44067.80 (48347.34)	-8126.44 (9355.91)	0.49 (2.04)	0.40 (2.21)
Revenues 2004-2003 (Mio. Euro)	4.58*** (0.71)	4.29*** (0.70)	4.43*** (0.93)	4.38*** (0.62)	0.02*** (0.01)	0.02*** (0.01)
Revenues 2003 (Mio. Euro)	0.05 (0.28)	-	-0.71 (1.38)	-	0.00** (0.00)	-
No. Employees 2003	-0.05 (0.11)	-	0.22 (0.52)	-	0.00*** (0.00)	-0.02*** (0.00)
No. Employees 2004-2003	-1.00*** (0.04)	-1.01*** (0.04)	-1.15*** (0.16)	-1.05*** (0.05)	-1.00*** (0.00)	-1.01*** (0.00)
No. Employees 2003-2002	-0.85 (0.80)	-	-1.40 (1.98)	-	0.00 (0.00)	-
Mining	486.99 (316.47)	373.76* (193.43)	323.98 (5404.09)	-	-4.86 (8.01)	-
Electricity	562.16* (307.10)	431.50** (183.63)	8032.52 (11732.76)	-	0.62 (3.76)	-
Energy	576.89** (280.85)	460.36*** (178.56)	3036.61 (5619.92)	-	9.57** (4.77)	-
Business	555.29* (315.56)	394.59* (228.14)	-4859.04 (6423.88)	-	6.85 (5.62)	-
Pulp & Paper	565.95* (320.64)	432.77** (186.05)	-1540.41 (3394.63)	-	-0.62 (4.07)	-
Coke & Petroleum	624.19** (273.35)	512.96*** (192.22)	6473.68 (7243.06)	-	11.07 (8.56)	-
Other Manufacturing	285.82 (365.37)	-	-235.53 (2741.93)	-	4.31 (3.02)	-
Constant Term	-642.96* (388.52)	-467.25** (198.56)	53153.02 (58410.43)	9668.14 (11335.02)	-3.32 (3.17)	4.37 (3.03)
No. Obs.	419	419	419	419	415	416
R-squared	0.85	0.83	0.85	0.35	-	-
F-Test (p-Val.)	0.00	0.00	0.00	0.00	0.00	0.00
F-Test on excl. exp. var. (p-Val.)	-	0.00	-	0.96	-	0.21

Note: Dep. var.: Employees 2005-2004. Std. errors in brackets (OLS, 2SLS: White robust std. errors). *, ** and *** show significance at the 10%-, 5%-, and 1%-level, respectively.

Appendix Chapter 2.3.

Table A. 9 Descriptive Statistics Dataset

	Mean	Std. Dev.	Min.	Max.	Obs.
Environmental Expenditures	399.92	630.59	6.67	3450.28	161
Environmental Investment	66.65	92.86	0.03	544.02	161
Energy Expenditures	874.43	1052.88	24.36	4101.92	161
ICT Investment	464.58	427.58	6.26	1916.18	161
Other Investment	2058.89	2204.23	56.47	11143.12	161
R&D Expenditures	1288.44	2194.17	2.82	10823.03	161
Gross Salaries	9491.03	9707.89	183.73	37619.31	161
Social Security Contributions	2328.93	2425.38	41.95	10508.29	161
HHI	50.01	72.21	1.44	266.48	161
Turnover	0.18	0.11	0.05	0.92	161
Hours Worked	267189.70	252448.10	10151.00	943605.00	161
Quality of Labor	0.38	0.12	0.23	0.69	161
Gross Value Added	17046.89	15316.99	490.00	57510.00	161
Gross Value Added Growth	223.55	1527.92	-4600.00	8060.00	138

Note: All monetary data is given in Mio. Euro and is measured in 1995 prices.

Table A. 10 Correlations

	Environ-mental Expendi-tures	Environ-mental Invest-ment	Energy Expendi-tures	ICT Invest-ment	Other Invest-ment	R&D Expendi-tures	Gross Salaries	Social Sec. Contribu-tions	HHI	Turnover	Hours Worked	Quality of Labor	Gross Value Added	Gross Value Added Growth
Environmental Expenditures	1.00													
Environmental Investment	0.94	1.00												
Energy Expenditures	0.87	0.79	1.00											
ICT Investment	0.49	0.54	0.50	1.00										
Other Investment	0.59	0.61	0.63	0.83	1.00									
R&D Expenditures	0.46	0.47	0.38	0.65	0.84	1.00								
Gross Salaries	0.39	0.40	0.48	0.91	0.88	0.72	1.00							
Social Security Contributions	0.45	0.46	0.52	0.91	0.91	0.77	0.99	1.00						
HHI	-0.38	-0.05	-0.25	0.03	-0.09	0.05	-0.12	-0.09	1.00					
Turnover	-0.22	-0.12	-0.20	-0.17	-0.20	-0.15	-0.16	-0.16	-0.08	1.00				
Hours Worked	0.92	0.31	0.47	0.83	0.81	0.54	0.94	0.91	-0.25	-0.17	1.00			
Quality of Labor	0.13	0.10	-0.14	0.09	-0.07	0.10	-0.06	-0.05	0.41	-0.09	-0.27	1.00		
Gross Value Added	0.68	0.68	0.82	0.87	0.95	0.75	0.98	0.98	-0.38	-0.22	0.92	0.05	1.00	
Gross Value Added Growth	0.07	0.11	-0.06	-0.04	-0.10	-0.02	-0.15	-0.13	0.23	0.13	-0.19	0.09	-0.07	1.00

Notes: 138 observations. All variables are in logs.

Table A. 11 Estimation Results

	OLS	OLS	LSDV with time (year) dummies	LSDV with time (year) dummies	LSDVC with time (year) dummies	LSDVC with time (year) dummies	GMM DIF with time (y.) dummies	GMM DIF with time (y.) dummies
Env. Expenditures	0.04 (0.03)	0.06 (0.05)	0.23** (0.11)	0.31*** (0.09)	0.20 (0.13)	0.24** (0.11)	0.00 (0.10)	0.02 (0.12)
Env. Investment	0.06 (0.04)	0.03** (0.02)	0.07* (0.04)	0.07** (0.03)	0.05 (0.04)	0.05* (0.03)	0.06** (0.02)	0.06** (0.03)
Energy Expenditures	-0.04 (0.03)	-0.11** (0.05)	-0.02 (0.12)	-0.07 (0.11)	0.03 (0.14)	0.01 (0.12)	0.05 (0.08)	0.03 (0.08)
ICT Investment	0.12 (0.08)	-	0.52** (0.24)	-	1.08*** (0.29)	1.08*** (0.27)	1.36*** (0.37)	1.29*** (0.33)
Other Investment	-0.12 (0.12)	-	-0.20** (0.08)	-0.18*** (0.07)	-0.20** (0.09)	-0.16** (0.08)	-0.23*** (0.08)	-0.23* (0.09)
R&D Expenditures	0.02** (0.01)	-	-0.00 (0.10)	-	-0.01 (0.11)	-	-	-
Gross Salaries	0.56* (0.31)	-	-0.22 (0.57)	-	-0.57 (0.73)	-1.02** (0.50)	-0.42 (0.43)	-
Social Security Contributions	-0.50* (0.29)	-	-0.59* (0.36)	-	-0.49 (0.37)	-	-0.55 (0.45)	-0.63* (0.37)
HHI	0.02 (0.01)	-	0.06 (0.09)	-	-0.01 (0.09)	-	0.08 (0.08)	-
Turnover	0.06* (0.03)	-	0.10 (0.12)	-	-67.48** (31.55)	-	0.02 (0.09)	-
Hours Worked	-0.04 (0.07)	-	0.38 (0.46)	-	-0.07 (0.15)	-	0.66** (0.30)	0.42* (0.22)
Quality of Labor	-0.04 (0.07)	-	0.49 (0.70)	-	0.37 (0.73)	-	0.91** (0.44)	0.69* (0.38)
Gross Value Added Growth (t-1)	-	-	-	-	-0.43*** (0.08)	-0.45*** (0.08)	0.21** (0.11)	0.21** (0.10)
Constant Term	-0.02 (0.51)	0.26*** (0.08)	-0.56 (3.25)	-0.08 (0.75)	-	-	1.27 (1.88)	1.59 (2.03)
No. Obs.	138	138	138	138	115	115	115	115
R-sq.	0.24	0.22	0.31	0.25	-	-	-	-
F-Test	1.51	2.40**	2.64***	4.34***	-	-	-	-
Wald-Test	-	-	-	-	-	-	15132.94***	2631.96***
m1	-1.35	-1.13	-	-	-	-	-2.16**	-2.16**
m2	-0.67	-0.70	-	-	-	-	-0.49	0.01
Sargan	-	-	-	-	-	-	91.85	94.13

Notes: Dep. var.: Gross Value Added Growth (log). Huber-White robust standard errors in brackets (std. errors of LSDVC based on bootstrapping procedure). *, ** and *** show significance at the 10%-, 5%-, and 1%-level, respectively. All estimations include time (year) dummies in the regression equations (parameter estimates not reported). m1 and m2 show the z-statistics for first- and second-order serial correlation, respectively. Sargan refers to the Sargan test for overidentifying restrictions. For GMM DIF, Hours Worked, Quality of Labor, Environmental Expenditures, Environmental Investment, ICT Investment, Other Investment, Gross Salaries, Social Security Contributions, and Energy Expenditures are treated instrumented with lagged levels.

Table A. 12 First Stage Regressions

	Environmental Expenditures	**Environmental Investment**	*Energy Expenditures*
F-Test	3.37***	2.68***	3.46***

Notes: Regressions using the first, or first and second lags of Hours Worked, Quality of Labor, Environmental Expenditures, Environmental Investment, ICT Investment, R&D Expenditures, Other Investment, Gross Salaries, Social Security Contributions, and Energy Expenditures (besides the regular alternative explanatory variables of the second stage regressions) as explanatory variables. *, ** and *** show significance at the 10%-, 5%-, and 1%-level, respectively. The respective complete first stage regression results for all instrumented variables are available on request from the authors.

Appendix Chapter 3.1.

Table A. 13 Dickey-Fuller Unit Root Tests

Variable	*Test Statistic*
r	-21.187***
r_m	-21.827***
r_{EUA}	-18.287***
v_{EUA}	-15.932***
r_o	-24.876***
v_o	-23.852***
r_g	-21.276***
v_g	-21.891***
r_e	-30.318***
v_e	-16.158***

Note: *** shows significance (rejection of the null hypothesis of a unit root) at the 1%-level.

Table A. 14 Correlation Matrix

	r	r_m	r_{EUA}	v_{EUA}	r_o	v_o	r_g	v_g	r_e	v_e
r	1.0000									
r_m	0.5660	1.0000								
r_{EUA}	0.1162	-0.0108	1.0000							
v_{EUA}	-0.0820	-0.0953	-0.1635	1.0000						
r_o	0.1044	0.0522	0.0805	-0.0628	1.0000					
v_o	0.0316	0.0116	0.0098	0.0697	-0.1106	1.0000				
r_g	0.1290	0.0694	0.1611	-0.0117	0.0586	0.0328	1.0000			
v_g	0.0350	0.0149	0.0580	-0.0156	-0.0227	-0.0153	0.6169	1.0000		
r_e	-0.0031	0.0356	-0.0416	-0.0091	-0.0021	-0.0414	-0.0144	-0.0447	1.0000	
v_e	0.0276	0.0421	0.0004	-0.0325	0.0703	-0.0097	0.0140	-0.0089	-0.1329	1.0000

Note: 481 observations. Pearson's correlation coefficients for the respective variable pairs are given.

Appendix Chapter 3.2.

Table A. 15 Summary Statistics

	Mean	*Std. Error*
$r_{Utility}$	0.0003235	0.0003094
$r_{Oil\ and\ Gas}$	0.0005333	0.0003396
r_m	-0.0000004	0.0003344
r_o	0.0005622	0.0005163
w_o	0.0003906***	0.0000182
v_o	-0.0000006	0.0000181
z_o	0.0150278***	0.0003318
r_g	-0.0001254	0.0012385
w_g	0.0022457***	0.0002806
v_g	0.0000014	0.0002806
z_g	0.0255729***	0.0010417
r_c	0.0009255	0.0007443
w_c	0.0008119***	0.0002245
v_c	0.0000006	0.0002245
z_c	0.0084896***	0.0007105
r_t	0.0000434	0.0000805
r_x	0.0002720*	0.0001416

Note: *, ** and *** show significance at the 10%-, 5%-, and 1%-level, respectively.

Table A. 16 Dickey-Fuller Unit Root Tests

	Test Statistic
$r_{Utility}$	-38.895***
$r_{Oil\ and\ Gas}$	-35.831***
r_m	-38.300***
r_o	-41.894***
w_o	-35.823***
v_o	-38.256***
z_o	-36.721***
r_g	-36.882***
w_g	-37.143***
v_g	-38.256***
z_g	-32.685***
r_c	-38.348***
w_c	-38.557***
v_c	-38.252***
z_c	-39.277***
r_t	-31.339***
r_x	-38.864***

Note: Results of Dickey-Fuller unit root tests (null hypothesis: unit root) without trend term reported. According to visual inspection, none of the series exhibits trends. *** shows rejection of null hypothesis at the 1%-level.

Table A. 17 Correlation Matrix

	$r_{Utility}$	$r_{Oil\ Gas}$	r_m	r_o	w_o	v_o	z_o	r_g	w_g	v_g	z_g	r_c	w_c	v_c	z_c	r_t	r_x
$r_{Utility}$	1.0000																
$r_{Oil\ Gas}$	0.6456	1.0000															
r_m	0.8318	0.7357	1.0000														
r_o	-0.0117	0.1734	0.0473	1.0000													
w_o	-0.0016	-0.0383	0.0092	-0.0146	1.0000												
v_o	-0.0081	-0.0448	0.0058	-0.0135	0.9881	1.0000											
z_o	0.0148	-0.0242	0.0162	-0.0466	0.9081	0.9014	1.0000										
r_g	0.0282	0.0201	0.0054	0.0483	-0.0147	-0.0084	0.0007	1.0000									
w_g	-0.0210	-0.0094	-0.0334	-0.0080	-0.0306	-0.0239	-0.0320	0.5780	1.0000								
v_g	-0.0222	-0.0094	-0.0334	-0.0080	-0.0306	-0.0239	-0.0306	0.5780	1.0000	1.0000							
z_g	-0.0272	-0.0090	-0.0472	-0.0009	-0.0405	-0.0343	-0.0433	0.4472	0.8772	0.8749	1.0000						
r_c	-0.0125	-0.0019	0.0246	0.0603	-0.0073	-0.0059	-0.0056	0.1456	0.2290	0.2294	0.2061	1.0000					
w_c	-0.0070	-0.0045	-0.0147	0.0224	-0.0106	-0.0080	-0.0094	0.1672	0.1920	0.1921	0.2227	0.2502	1.0000				
v_c	-0.0066	-0.0040	-0.0142	0.0226	-0.0104	-0.0079	-0.0093	0.1673	0.1919	0.1920	0.2228	0.2503	1.0000	1.0000			
z_c	-0.0130	-0.0107	-0.0319	0.0077	-0.0157	-0.0116	-0.0187	0.2416	0.3413	0.3419	0.3671	0.2430	0.8671	0.8670	1.0000		
r_t	0.2365	0.2589	0.2759	-0.0498	-0.0018	-0.0038	0.0018	-0.0057	-0.0123	-0.0115	-0.0095	0.0031	0.0139	0.0140	0.0162	1.0000	
r_x	-0.1859	-0.1305	-0.2575	-0.1700	0.0020	0.0027	0.0030	-0.0139	0.0435	0.0435	0.0592	-0.1635	0.0092	0.0086	0.0704	-0.0425	1.0000

Note: 1466 observations. Pearson's correlation coefficients for the respective variable pairs are given.

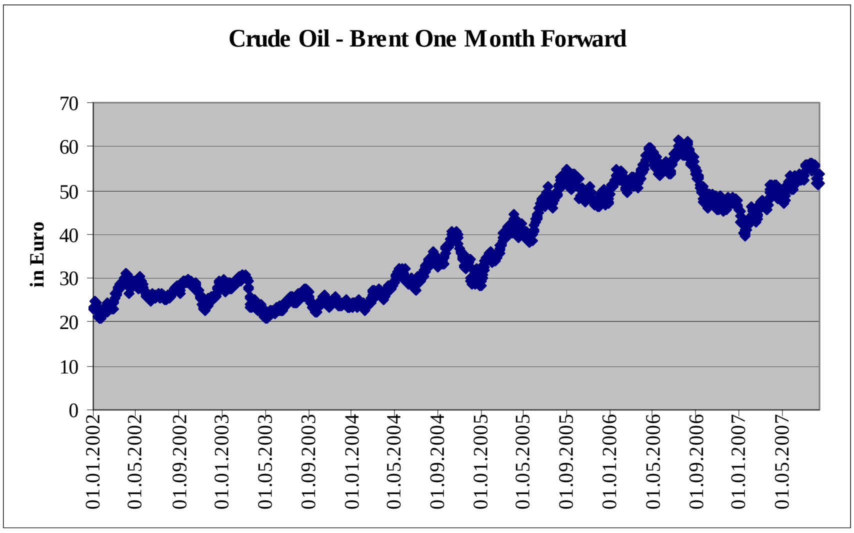

Figure A. 1 Price Oil Forward (Euro per Barrel)

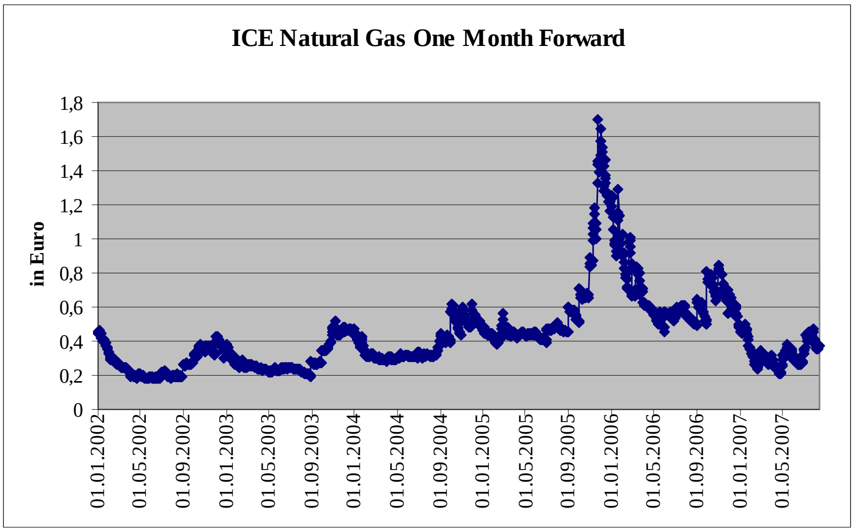

Figure A. 2 Price Gas Forward (Euro per 100.000 British Thermal Units)

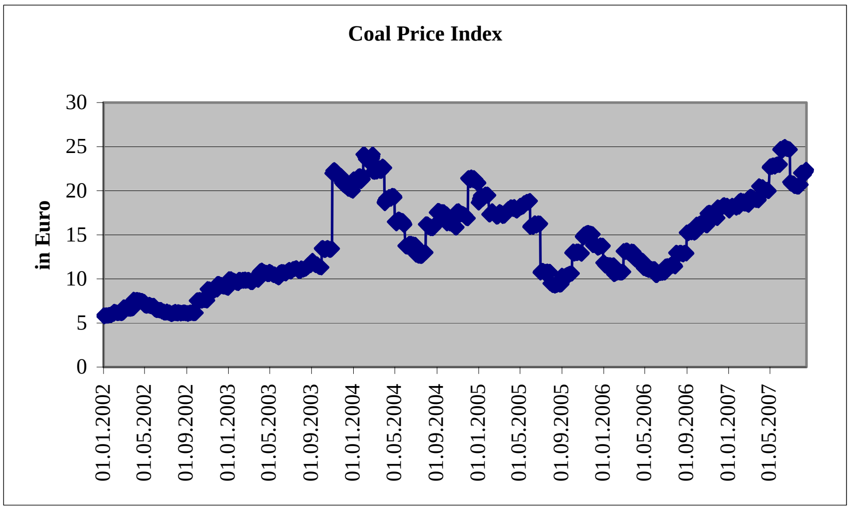

Figure A. 3 Coal Price Index (Euro per Gigajoule)

Table A. 18 Results Utility Portfolio

	OLS $v_{j,t}$	***GARCH (1,1)*** $v_{j,t}$	***OLS*** $w_{j,t}$	***GARCH (1,1)*** $w_{j,t}$	***OLS*** $z_{j,t}$	GARCH (1,1) $z_{j,t}$
Mean Equation						
const	0.00*	0.00***	0.00**	0.00***	0.00	0.00*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Market	0.78***	0.78***	0.78***	0.78***	0.78***	0.78***
	(0.02)	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)
Oil Price Change	-0.03***	-0.03***	-0.03***	-0.03***	-0.03***	-0.03***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Gas Price Change	0.01	0.01	0.01	0.01	0.01	0.00
	(0.01)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)
Coal Price Change	-0.01***	-0.01*	-0.01***	-0.01*	-0.01**	-0.01*
	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Interest Rate Change	0.01	0.03	0.01	0.03	0.01	0.03
	(0.07)	(0.05)	(0.07)	(0.05)	(0.07)	(0.05)
Exchange Rate Change	0.03	0.03	0.03	0.03	0.03	0.03
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Oil Volatility	-0.21	-0.25	-0.18	-0.23	-0.00	-0.01
	(0.25)	(0.26)	(0.25)	(0.26)	(0.01)	(0.01)
Gas Volatility	-0.01	-0.01	-0.01	-0.01	0.00	-0.00
	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.00)
Coal Volatility	0.01	0.01	0.01	0.01	0.01	0.01
	(0.01)	(0.03)	(0.01)	(0.03)	(0.01)	(0.01)
Variance Equation						
const	-	0.00***	-	0.00***	-	0.00***
		(0.00)		(0.00)		(0.00)
GARCH (1) Term	-	0.88***	-	0.88***	-	0.88***
		(0.02)		(0.02)		(0.02)
ARCH (1) Term	-	0.07***	-	0.07***	-	0.07***
		(0.01)		(0.01)		(0.01)
Obs.	1466	1466	1466	1466	1466	1466
R-squared	0.70	-	0.70	-	0.70	-
F-Test	181.55***	-	181.42***	-	182.28***	-
Wald-Test (Chi-sq.)	-	4038.46***	-	4039.53***	-	4050.87***
ARCH (Chi-sq.)	75.40***	-	75.54***	-	75.86***	-
BG-Autoc. (Chi-sq.)	3.78*	-	3.78*	-	3.73*	-
Durb. Autoc. (Chi-sq.)	3.76*	-	3.76*	-	3.71*	-
RESET (F)	0.23	-	0.23	-	0.21	-

Note: Newey-West autocorrelation and heteroskedasticity-robust standard errors in brackets (OLS estimations). *, ** and *** show significance at the 10%-, 5%-, and 1%-level, respectively.

Table A. 19 Results Oil and Gas Portfolio

	OLS ***$v_{j,t}$***	***GARCH*** ***(1,1) $v_{j,t}$***	***OLS*** ***$w_{j,t}$***	***GARCH*** ***(1,1) $w_{j,t}$***	***OLS*** ***$z_{j,t}$***	GARCH (1,1) $z_{j,t}$
Mean Equation						
const	0.00*	0.00***	0.00***	0.00***	0.00*	0.00**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Market	0.74***	0.72***	0.74***	0.72***	0.74***	0.72***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Oil Price Change	0.10***	0.08***	0.10***	0.08***	0.10***	0.08***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Gas Price Change	0.00	-0.00	0.00	-0.00	0.00	-0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)
Interest Rate Change	0.29***	0.24***	0.29***	0.24***	0.29***	0.24***
	(0.08)	(0.06)	(0.08)	(0.06)	(0.08)	(0.06)
Exchange Rate Change	0.21***	0.15***	0.21***	0.15***	0.21***	0.15***
	(0.05)	(0.04)	(0.05)	(0.04)	(0.05)	(0.04)
Oil Volatility	-0.81***	-0.66***	-0.79***	-0.63**	-0.03*	-0.02*
	(0.32)	(0.28)	(0.31)	(0.28)	(0.02)	(0.01)
Gas Volatility	0.01	0.02	0.01	0.02	0.01	0.01
	(0.03)	(0.03)	(0.03)	(0.03)	(0.01)	(0.01)
Variance Equation						
const	-	0.00***	-	0.00***	-	0.00***
		(0.00)		(0.00)		(0.00)
GARCH (1) Term	-	0.89***	-	0.89***	-	0.89***
		(0.02)		(0.02)		(0.02)
ARCH (1) Term	-	0.07***	-	0.07***	-	0.07***
		(0.01)		(0.01)		(0.01)
Obs.	1466	1466	1466	1466	1466	1466
R-squared	0.57	-	0.57	-	0.57	-
F-Test	162.05***	-	161.82***	-	160.65***	-
Wald-Test (Chi-sq.)	-	2267.04***	-	2267.11***	-	2275.40***
ARCH (Chi-sq.)	37.58***	-	37.54***	-	38.00***	-
BG-Autoc. (Chi-sq.)	0.88	-	0.88	-	0.85	-
Durb. Autoc. (Chi-sq.)	0.87	-	0.88	-	0.84	-
RESET (F)	3.44**	-	3.43**	-	3.59**	-

Note: Newey-West autocorrelation and heteroskedasticity-robust standard errors in brackets (OLS estimations). *, ** and *** show significance at the 10%-, 5%-, and 1%-level, respectively.

Appendix Chapter 3.3.

Table A. 20 Unit Root Tests Full Sample Period (10/1973-01/2008)

	Levels			1st Differences		
	ADF	**PP**	**KPSS**	**ADF**	**PP**	**KPSS**
Unemployment	-2.70	-4.69***	0.35***	4.46***	-11.22***	0.06
Oil price (oil)	-1.99	-2.09	0.31***	-11.73***	-11.31***	0.18**
Oil price increase (dloilpos)	-12.38***	-11.99***	0.08	-	-	-
Net oil price increase (nopi)	-11.70***	-11.30***	0.11	-	-	-
Interest rate	-2.86	-2.35	0.18**	-6.35***	-26.67***	0.08
Industrial production	-3.05	-11.46***	0.11	-4.72***	-46.51***	0.05

Note: ADF: Augmented Dickey-Fuller Test (null hypothesis: unit root), PP: Phillips-Perron Test (null hypothesis: unit root), KPSS: Kwiatkowski-Phillips-Schmidt-Shin Test (null hypothesis: stationarity). *, ** and *** show rejection of null hypothesis at the 10%-, 5%-, and 1%-level, respectively. Unit root tests include linear time trend. Lag length according to Schwarz Information Criterion. 393 obs.

Table A. 21 Unit Root Tests Post-Unification Sample (10/1990-01/2008)

	Levels			1st Differences		
	ADF	**PP**	**KPSS**	**ADF**	**PP**	**KPSS**
Unemployment	-4.63***	-4.84***	0.28***	4.48***	-11.17***	0.13*
Oil price (oil)	-3.16*	-2.60	0.34***	-10.23***	-10.03***	0.04
Oil price increase (dloilpos)	-11.79***	-11.78***	0.06	-	-	-
Net oil price increase (nopi)	-11.63***	-11.83***	0.06	-	-	-
Interest rate	-2.02	-0.97	0.22***	-3.91**	-11.72***	0.08
Industrial production	-2.63	-8.81***	0.29***	-2.89	-50.26***	0.18**

Note: ADF: Augmented Dickey-Fuller Test (null hypothesis: unit root), PP: Phillips-Perron Test (null hypothesis: unit root), KPSS: Kwiatkowski-Phillips-Schmidt-Shin Test (null hypothesis: stationarity). *, ** and *** show rejection of null hypothesis at the 10%-, 5%-, and 1%-level, respectively. Unit root tests include linear time trend. Lag length according to Schwarz Information Criterion. 208 obs.

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Ehrenwörtliche Erklärung

Hiermit erkläre ich, dass ich diese Dissertation selbständig verfasst und ohne Benutzung anderer als der angegebenen Hilfsmittel angefertigt habe. Die aus anderen Quellen direkt oder indirekt übernommenen Daten und Konzepte sind unter Angabe der Quelle gekennzeichnet. Diese Arbeit wurde nicht schon als eine Diplom- oder ähnliche Prüfungsarbeit einer anderen Prüfungsbehörde vorgelegt.

Mannheim, 09. November 2008

Ulrich Oberndorfer