Clean energy firms' stock prices, technology, oil prices, and carbon prices

Mara Madaleno
University of Aveiro Aveiro

Alfredo Marvão Pereira
The College of William and Mary

College of William and Mary
Department of Economics
Working Paper Number 162

First Version: June 2015

.COLLEGE OF WILLIAM AND MARY
DEPARTMENT OF ECONOMICS
WORKING PAPER # 162
June 2015

Clean energy firms' stock prices, technology, oil prices, and carbon price

Abstract: Production costs of alternative energies are still high, but increased demand for oil, future oil supply shortage concerns and climate change concerns, have led to the fast development of renewable energy firms. The sector accomplished has accomplished remarkable progress and attracted attention to clean energy, both at the industry level and at the academic side. With this work we attempt to determine whether or not the placement of a price on carbon emissions encourages investments in clean energy firms. Unlike previous literature we focus on the German case and we address the issue at the individual company level. We were able to verify this link but only for the case of companies whose weight over the amount of total energy produced is relevant, which is the case of solar in Germany.

Keywords: Clean Energy; Firm Stock Prices; Oil Prices; Carbon Prices; Technology.

Mara Madaleno
Department of Economics, Management and Industrial Engineering, , DEGEI, GOVCOPP, University of Aveiro Aveiro, Portugal,
maramadaleno@ua.pt

Alfredo Marvão Pereira
Department of Economics,
The College of William and Mary, Williamsburg, USA
PO Box 8795, Williamsburg, VA 23187
ampere@wm.edu

Clean energy firms' stock prices, technology, oil prices, and carbon prices

Mara Madaleno
Department of Economics, Management and Industrial Engineering, DEGEI, GOVCOPP, University of Aveiro
Aveiro, Portugal
maramadaleno@ua.pt

Alfredo Marvão Pereira
Department of Economics
The College of William and Mary
Williamsburg, Virginia, United States
ampere@wm.edu

***Abstract*—Production costs of alternative energies are still high, but increased demand for oil, future oil supply shortage concerns and climate change concerns, have led to the fast development of renewable energy firms. The sector accomplished has accomplished remarkable progress and attracted attention to clean energy, both at the industry level and at the academic side. With this work we attempt to determine whether or not the placement of a price on carbon emissions encourages investments in clean energy firms. Unlike previous literature we focus on the German case and we address the issue at the individual company level. We were able to verify this link but only for the case of companies whose weight over the amount of total energy produced is relevant, which is the case of solar in Germany.**

***Index Terms*—Clean Energy; Firm Stock Prices; Oil Prices; Carbon Prices; Technology.**

I. INTRODUCTION

Climate change, resource scarcity of fossil fuels, energy security issues, and the development of new technologies have driven the debate, attention and scientific exploration regarding clean energy. The quick increase in demand in emerging economies (mostly China and India) and future oil supply shortages concerns (according to [1], world oil production is estimated to peak between 2016 and 2040) are expected ultimately to lead to higher oil prices in the future. Energy security issues and increased concern over the natural environment are also driving factors behind oil price movements. Moreover, the growing interest on renewable energy may be related to the development of new technologies and environmentally conscious consumers [2].

All of these issues suggest that economies need to protect themselves by substituting away from oil to alternative energy sources. Accordingly, they have also caused a surge in alternate energy investments. Indeed, the renewable energy sector has accomplished remarkable progress at the global level during the last decade. At the global level, it has been estimated that private and public investment in renewable energy climbed from 20 billion US$ in 2008 up to 150 billion in 2009. Nevertheless, the total investment in renewables is just a very modest 0.26 percent of the global GDP. There is, therefore, huge room for expansion of the clean energy sectors.

The economics literature has followed these developments. In [3], the authors use a five-variable vector autoregressive model (VAR) using weekly data for stock prices of clean energy firms, technology stock prices, oil prices, carbon prices, and the interest rate. It argues that global climate change drive the growth of alternative energy sources (less carbon intensive), inducing a positive relationship between the price of carbon emission permits and the stock prices of alternative energy sources. In [4] a Markov-Switching VAR is used relating oil prices, clean energy, technology stock prices and interest rates. It finds a positive relationship between oil prices and clean energy prices after accounting for structural changes. It also argues in favor of the existence of a similarity in terms of market responses to both clean energy stock prices and technology stock prices. In turn, [5] document the return and volatility spillover effects between the stock prices of Chinese new energy and fossil fuel companies using the asymmetric BEKK model and daily data between 30 August 2006 and 11 September 2012. Their empirical results show that new energy and fossil fuel stocks are competing assets; that positive news about new energy stocks could affect the attractiveness of fossil fuel stocks and that new energy stock investment is more speculative and riskier than fossil fuel stock investment. In [6] a VAR is employed using daily data from 3 January 2001 until 30 May 2007 to study the relationship between clean energy stock prices and oil prices. The authors find that there is little impact of oil prices but a significant impact from technology stock prices on stock prices of alternative energy companies. In [7] the contribution to this empirical analysis is pursued at the company level considering a sample of 560 US companies divided into 14 sectors. Using a GARCH model, it shows that different economic sectors are affected in a different way by changes in oil prices. The transport and energy sectors are positively impacted by oil price increases while the other sectors are negatively impacted.

With this empirical evidence in mind, our main goal in this note is to explore how oil prices, carbon prices, technology stocks and individual stock returns are related to each other. The main goals of this work are: first, to explore at the firm level the links between clean energy stock prices, oil prices, carbon prices, and technology stock prices (as in [3], but at the company level and considering the fact that from 2014 onwards oil prices faced a sharp drop); second, to account for the relationships among the different variables at the individual firm level, while endogenously controlling for structural changes in the market such as the financial crisis, big oil price increases/decreases, and changes in the carbon allowances markets (in the spirit of [4]); third, to see if at the individual stock company data the result of a significant relationship between carbon prices and the stock prices of the firms continues to fail to be identified (as in [3]); fourth, to understand how sensitive the financial performance of alternative individual energy companies are to changes in oil prices, technology stock prices and carbon prices (in the spirit of [6]).

Policymakers, with these results, would be able to judge which type of policies leverage significantly new energy stock investments and the extent to which the relevant financing channel, for energy development; the energy related stock market is able to turn easier the economy transition to a green market. Fossil fuel companies should be aware of the downside risks for fossil fuel stock prices in the context of current energy policy. Opposite and favorable fossil fuel policies (mainly the upward adjustment of product oil prices) are not expected to stimulate new energy stock investments in some cases. As such, different energy policy combinations could have different effects on the stability of energy stock investments and a higher effort should be placed to guarantee new energy development.

II. Data and Methodology

A. Data

In this work, we use weekly data from the German stock market. We select to work with the German market because renewables contributing 23.9 per cent of gross electricity production in Germany in 2013. In 2012 Germany had one third of the world's solar panels, and at one point these panels generated a lot of Germany's electricity, thus justifying the inclusion of more solar energy companies into our sample. In fact, in [8] we can read "Comparing countries' share of renewable energy in their energy supply, the map shows that European countries rank best in using low carbon resources for their energy production. Germany's "energy transition" could prove to be a role model for other countries to reduce their fossil fuel consumption." (p. 14). In this report USA and China are marked as "poor" performers, despite their massive investment in renewable energy in recent years. This further justifies changing the market analysis focus to the German case away from focusing on these countries, as in the previous literature.

We collected daily data for the thirty one green companies listed in the German market. Due to space limitations we have selected ten of these to report here. These ten companies were chosen as representative of the different types of renewable energy produced. Their names, activity, source, and start date are described in Table 1.

Table 1: Data Set

Company	Var. Name	Start date	Activity	Weekly observ.	Source
BIOGAS NORD	r4	12/14/2006	Constructs **biogas** plants	309	deutsche-boerse.com
CROPENERGIES	r10	10/2/2006	Produces **biotethanol**	319	deutsche-boerse.com
HELIOCENTRIS EN.SLTN.	r12	6/26/2006	**Fuel cell** system platforms	333	deutsche-boerse.com
NORDEX	r15	8/5/2005	**Wind** energy	379	deutsche-boerse.com
PETROTEC	r17	11/6/2006	**Biodiesel** producers from waste	314	deutsche-boerse.com
S&O AGRAR	r20	8/5/2005	**Biogas** facilities	379	deutsche-boerse.com
SOLON	r27	8/5/2005	**Solar** energy production	379	deutsche-boerse.com
SUNLINE	r29	10/20/2005	**Solar** energy production	369	deutsche-boerse.com
SUNWAYS	r30	8/5/2005	**Solar** energy supply	379	deutsche-boerse.com
VERBIO VER.BIOENERGIE	r31	10/16/2006	**Biodiesel**, **bioethanol** producers	317	deutsche-boerse.com
All renewable energies index dax	rdax	3/31/2008		242	deutsche-boerse.com
BD EU-MARK 3M DEPOSIT (FT/TR) - MIDDLE RATE	rir	8/4/2005		379	www.bundesbank.de
EEX-EU CO2 EMISSIONS E/EUA - spot market	reexco2	8/5/2005		379	www.eex.com
Germany-DS Technology price index (TecDax)	rtgr	8/5/2005		379	deutsche-boerse.com
Europe Brent Spot Price FOB (Dollars per Barrel)	reubt	8/5/2005		379	www.eia.gov

For each of the remaining variables we considered alternative possibilities. With respect to carbon prices, we have data from the EEX-EU CO2 emissions E/EUA, the Settlement price CO2, Reuters CER 1-pos E/mt and the CO2, Reuters CER 2-pos E/mt EUR. With respect to technology indices we have daily data from the Germany-DS technology price index and the PSE adjustment close price. Finally, oil prices series were collected with respect to: Cushing, OK WTI Spot Price FOB (dollars per barrel) and Europe Brent Spot Price FOB (dollars per barrel).

All daily series were transformed into weekly observations by using the value of every Wednesday in the spirit of [3]. The data period goes from: 05-08-2005 until 28-11-2012 (changing with respect to start date depending on the series; see again Table 1). Furthermore, all price series have been transformed into log-levels.

B. Methodology

The methodology used is a vector autoregressive analysis. We consider weekly five-variable VARs to study the relationship among the different variables for each of the 10 clean energy companies stock prices as well as for the all renewable energies index DAX for a total of 11 VAR models. The remaining variables are the same in all cases: the stock index of technology companies in Germany, oil prices, carbon prices and the interest rate.

We start by performing descriptive statistics and correlation matrices of the data used. Next we study unit root properties of the data and to the optimal number of lags to be used in the estimations. Afterwards we present the results obtained through VAR estimations, their impulse response functions and variance decompositions.

When the issue of orthogonalization was pertinent, we followed the assumptions in [3].The oil price was treated as the most exogenous variable given that from the set it is the most independent one, once it mainly depends over OPEC's decisions regarding petroleum supply, although we may think of other factors able to affect it. After we have considered the carbon price and companies/index returns. Climate change concerns should induce the use of cleaner energies, while higher oil prices redirects users to other sources not always less pollutant, which should impact CO2 allowances prices in the market. Later these markets movements will be reflected in individual alternate company's returns. Furthermore, the technology index and the interest rate representative are left for last because we assume that only if alternate energy investments are made it is justified the jump over the technology index and this positive impact will also exert influence over the interest rate.

Considering all of the alternative data series for technology, carbon price, oil price, and interest rates as presented above, we find that our empirical results were not particularly sensitive to the specific series we select to work with for each variable. As such, we focus on the results pertaining to the series identified in Table 1.

III. EMPIRICAL RESULTS AND DISCUSSION

A. *Granger Causality*

In Table 2, we show the Granger causality tests. Granger causality tests indicate that the alternate DAX index is explained by oil returns and technology stock prices. In addition, r10 is Granger caused by carbon allowance prices and r12, r29 and r30 by high technology returns. So we cannot establish a behavioral pattern with respect to company's activity. Moreover, while oil returns Granger-causes high technology returns, the reverse impact only occurs for the renewables index rDAX and in r20 and r29 companies.

In all models we find that interest rates and the stock prices of clean energy companies are not related from a Granger causality perspective, contradicting [3] and [5], except for r15 and r17. There are only a few cases where carbon allowances Granger-cause oil prices, whereas oil prices help explain carbon allowances in all situations. In some situations, similar to [3], with the exception of r10, r15, r17, r27, r31, we see that carbon prices do not Grange-cause the stock prices of clean energy firms and vice-versa. This result may be due to the spot price series used for carbon allowances and not future prices. But it may also be due to the fact that carbon prices are too low to internalize the carbon externalities. In sum, from a Granger causality perspective, oil prices are not the only variable able to explain the stock price of alternative energy companies.

Also, and unlike the literature, when we perform this type of analysis with respect to individual clean energy firms, the interest rate does not Granger-cause the stock price of high technology firms or even in the opposite direction, and these results prevail independently of the company considered. This result may be justified by the low interest rates in recent years of our analysis and the low investment levels due to the financial crisis in Europe.

Table 2: Granger Causality Tests

Dep.	Excluded	Chi-sq	Prob.	Dep.	Excluded	Chi-sq	Prob.	Dep.	Excluded	Chi-sq	Prob.	Dep.	Excluded	Chi-sq	Prob.	Dep.	Excluded	Chi-sq	Prob.	Dep.	Excluded	Chi-sq	Prob.
REUBT	REEXCO2	5.333	0.255	REUBT	REEXCO2	10.151	**0.038**	REUBT	REEXCO2	10.691	**0.030**	REUBT	REEXCO2	8.941	**0.063**	REUBT	REEXCO2	10.227	**0.037**	REUBT	REEXCO2	8.482	**0.075**
	RDAX	10.223	**0.037**		R4	7.325	0.120		R10	4.777	0.311		R12	6.738	0.150		R15	3.873	0.423		R17	0.482	0.975
	RTGR	17.384	**0.002**		RTGR	6.818	0.146		RTGR	7.560	0.109		RTGR	6.144	0.189		RTGR	5.344	0.254		RTGR	8.809	**0.066**
	RIR	1.043	0.903		RIR	0.399	0.983		RIR	0.373	0.985		RIR	0.531	0.970		RIR	4.464	0.347		RIR	0.420	0.981
	All	34.274	**0.005**		All	25.905	**0.055**		All	22.286	0.134		All	23.714	**0.096**		All	24.583	**0.078**		All	17.465	0.356
REEXCO2	REUBT	35.721	**0.000**	REEXCO2	REUBT	35.989	**0.000**	REEXCO2	REUBT	36.349	**0.000**	REEXCO2	REUBT	31.831	**0.000**	REEXCO2	REUBT	42.350	**0.000**	REEXCO2	REUBT	35.708	**0.000**
	RDAX	8.439	**0.077**		R4	1.894	0.755		R10	7.647	0.105		R12	9.451	**0.051**		R15	9.507	**0.050**		R17	1.264	0.867
	RTGR	1.011	0.908		RTGR	1.939	0.747		RTGR	1.717	0.788		RTGR	1.016	0.907		RTGR	4.553	0.336		RTGR	2.752	0.600
	RIR	1.750	0.782		RIR	1.988	0.738		RIR	2.021	0.732		RIR	2.652	0.618		RIR	0.973	0.914		RIR	2.297	0.681
	All	51.134	**0.000**		All	45.859	**0.000**		All	53.213	**0.000**		All	56.601	**0.000**		All	55.887	**0.000**		All	45.316	**0.000**
RDAX	REUBT	13.966	**0.007**	R4	REUBT	4.006	0.405	R10	REUBT	6.124	0.190	R12	REUBT	4.981	0.289	R15	REUBT	5.351	0.253	R17	REUBT	1.768	0.778
	REEXCO2	2.317	0.678		REEXCO2	6.137	0.189		REEXCO2	8.692	**0.069**		REEXCO2	1.680	0.794		REEXCO2	4.312	0.366		REEXCO2	5.159	0.271
	RTGR	24.836	**0.000**		RTGR	4.665	0.324		RTGR	2.224	0.695		RTGR	10.368	**0.035**		RTGR	5.784	0.216		RTGR	4.749	0.314
	RIR	1.287	0.864		RIR	0.972	0.914		RIR	0.523	0.971		RIR	2.473	0.650		RIR	5.366	0.252		RIR	5.186	0.269
	All	56.037	**0.000**		All	16.046	0.450		All	18.257	0.309		All	21.058	0.176		All	19.629	0.237		All	15.233	0.508
RTGR	REUBT	11.015	**0.026**	RTGR	REUBT	8.982	**0.062**	RTGR	REUBT	7.556	0.109	RTGR	REUBT	7.553	0.109	RTGR	REUBT	7.347	0.119	RTGR	REUBT	8.605	**0.072**
	REEXCO2	6.741	0.150		REEXCO2	7.684	0.104		REEXCO2	6.664	0.155		REEXCO2	6.038	0.196		REEXCO2	9.527	**0.049**		REEXCO2	7.143	0.129
	RDAX	2.818	0.589		R4	17.026	**0.002**		R10	13.168	**0.011**		R12	5.313	0.257		R15	10.462	**0.033**		R17	2.158	0.707
	RIR	3.666	0.453		RIR	3.062	0.547		RIR	3.468	0.483		RIR	3.379	0.497		RIR	3.010	0.556		RIR	3.412	0.492
	All	24.541	**0.078**		All	38.411	**0.001**		All	34.194	**0.005**		All	25.333	**0.064**		All	30.999	**0.014**		All	22.341	0.133
RIR	REUBT	1.792	0.774	RIR	REUBT	2.185	0.702	RIR	REUBT	1.920	0.750	RIR	REUBT	1.632	0.803	RIR	REUBT	6.236	0.182	RIR	REUBT	1.717	0.788
	REEXCO2	1.303	0.861		REEXCO2	2.989	0.560		REEXCO2	4.192	0.381		REEXCO2	2.760	0.599		REEXCO2	0.411	0.982		REEXCO2	4.116	0.391
	RDAX	3.900	0.420		R4	2.158	0.707		R10	1.240	0.871		R12	3.842	0.428		R15	8.848	**0.065**		R17	16.231	**0.003**
	RTGR	2.061	0.725		RTGR	3.585	0.465		RTGR	1.455	0.835		RTGR	1.591	0.810		RTGR	2.107	0.716		RTGR	1.688	0.793
	All	9.701	0.882		All	9.916	0.871		All	9.227	0.904		All	11.943	0.748		All	19.082	0.265		All	24.476	**0.080**

Dep.	Excluded	Chi-sq	Prob.	Dep.	Excluded	Chi-sq	Prob.	Dep.	Excluded	Chi-sq	Prob.	Dep.	Excluded	Chi-sq	Prob.	Dep.	Excluded	Chi-sq	Prob.
REUBT	REEXCO2	8.612	**0.072**	REUBT	REEXCO2	4.316	0.116	REUBT	REEXCO2	9.399	**0.052**	REUBT	REEXCO2	9.553	**0.049**	REUBT	REEXCO2	9.169	**0.057**
	R20	4.869	0.301		R27	2.024	0.364		R29	1.737	0.784		R30	2.247	0.691		R31	3.050	0.549
	RTGR	9.278	**0.055**		RTGR	3.320	0.190		RTGR	8.894	**0.064**		RTGR	6.958	0.138		RTGR	9.256	**0.055**
	RIR	4.034	0.402		RIR	0.996	0.608		RIR	3.907	0.419		RIR	4.217	0.377		RIR	0.395	0.983
	All	25.637	**0.059**		All	11.878	0.157		All	22.636	0.124		All	22.862	0.118		All	20.435	0.201
REEXCO2	REUBT	38.571	**0.000**	REEXCO2	REUBT	23.883	**0.000**	REEXCO2	REUBT	38.398	**0.000**	REEXCO2	REUBT	41.104	**0.000**	REEXCO2	REUBT	35.519	**0.000**
	R20	0.166	0.997		R27	5.577	**0.062**		R29	1.022	0.906		R30	6.044	0.196		R31	10.660	**0.031**
	RTGR	3.243	0.518		RTGR	0.772	0.680		RTGR	2.726	0.605		RTGR	2.788	0.594		RTGR	2.570	0.632
	RIR	0.839	0.933		RIR	0.104	0.949		RIR	0.856	0.931		RIR	0.968	0.915		RIR	2.156	0.707
	All	45.353	**0.000**		All	31.060	**0.000**		All	45.698	**0.000**		All	51.981	**0.000**		All	56.386	**0.000**
R20	REUBT	1.988	0.738	R27	REUBT	4.278	0.118	R29	REUBT	3.172	0.530	R30	REUBT	6.439	0.169	R31	REUBT	1.897	0.755
	REEXCO2	0.058	1.000		REEXCO2	0.442	0.802		REEXCO2	0.335	0.987		REEXCO2	3.151	0.533		REEXCO2	6.921	0.140
	RTGR	2.614	0.624		RTGR	2.104	0.349		RTGR	11.105	**0.025**		RTGR	8.783	**0.067**		RTGR	6.992	0.136
	RIR	2.579	0.631		RIR	0.470	0.791		RIR	0.986	0.912		RIR	1.022	0.906		RIR	5.677	0.225
	All	6.436	0.983		All	7.854	0.448		All	14.423	0.567		All	16.599	0.412		All	19.333	0.252
RTGR	REUBT	8.697	**0.069**	RTGR	REUBT	5.970	**0.051**	RTGR	REUBT	8.653	**0.070**	RTGR	REUBT	6.135	0.189	RTGR	REUBT	9.774	**0.044**
	REEXCO2	8.111	**0.088**		REEXCO2	3.426	0.180		REEXCO2	8.255	**0.083**		REEXCO2	10.246	**0.037**		REEXCO2	7.966	**0.093**
	R20	2.554	0.635		R27	4.808	**0.090**		R29	4.209	0.379		R30	13.106	**0.011**		R31	18.112	**0.001**
	RIR	1.759	0.780		RIR	0.468	0.791		RIR	1.805	0.772		RIR	2.033	0.730		RIR	3.788	0.435
	All	22.646	0.124		All	17.223	**0.028**		All	24.046	**0.089**		All	33.793	**0.006**		All	39.649	**0.001**
RIR	REUBT	5.367	0.252	RIR	REUBT	3.653	0.161	RIR	REUBT	5.407	0.248	RIR	REUBT	4.684	0.321	RIR	REUBT	2.035	0.729
	REEXCO2	0.429	0.980		REEXCO2	0.194	0.907		REEXCO2	0.498	0.974		REEXCO2	0.414	0.981		REEXCO2	3.795	0.435
	R20	0.761	0.944		R27	1.822	0.402		R29	4.660	0.324		R30	7.421	0.115		R31	1.988	0.738
	RTGR	3.692	0.449		RTGR	0.621	0.733		RTGR	5.032	0.284		RTGR	4.731	0.316		RTGR	2.955	0.565
	All	10.767	0.824		All	7.701	0.463		All	14.582	0.555		All	17.615	0.347		All	9.962	0.869

B. *Variance Decomposition*

In Table 3 we have the results obtained for the variance decomposition considering horizons up to ten weeks. With respect to the all renewables DAX index, the variable which most contributes to the explanation of the variance of the error produced in the prediction of oil is technology, being followed by the index, while it is oil that most explanatory capacity has over carbon allowances followed by the DAX. There is an even higher influence of the technology index in terms of the explanatory capacity of the variance of the error produced in the prediction over the all renewables index, followed by oil, but it is oil that most influences technology. In terms of the interest rate, the impact of the other variables is almost marginal, thus reinforcing the previous results.

Table 3: Variance Decomposition

Cholesky Ordering: REUBT REEXCO2 RDAX RTGR RIR

Period	REUBT	REEXCO2	RDAX	RTGR	RIR
Variance Decomposition of REUBT:					
1	100.000	0.000	0.000	0.000	0.000
2	93.909	0.020	1.413	4.615	0.042
3	93.737	0.023	1.472	4.581	0.188
4	92.689	0.096	1.451	5.577	0.187
5	87.526	1.959	3.777	5.611	1.126
6	87.443	2.004	3.772	5.634	1.146
7	87.102	1.999	3.787	5.831	1.281
8	86.936	2.065	3.789	5.821	1.389
9	86.943	2.066	3.781	5.811	1.399
10	86.934	2.070	3.781	5.816	1.399
Variance Decomposition of REEXCO2:					
1	0.516	99.484	0.000	0.000	0.000
2	1.262	98.335	0.031	0.001	0.371
3	7.033	91.947	0.654	0.001	0.365
4	6.966	88.327	2.974	0.985	0.748
5	12.207	82.695	3.417	0.925	0.755
6	12.178	82.223	3.641	1.129	0.828
7	12.252	81.964	3.730	1.127	0.928
8	12.278	81.882	3.728	1.147	0.965
9	12.225	81.753	3.853	1.197	0.971
10	12.210	81.624	3.847	1.196	1.123
Variance Decomposition of RDAX:					
1	0.003	1.558	98.438	0.000	0.000
2	4.549	1.380	88.731	5.279	0.060
3	4.667	1.829	85.897	7.479	0.128
4	5.668	1.773	82.247	9.965	0.348
5	7.461	2.181	79.990	9.951	0.416
6	7.394	2.162	79.293	9.872	1.278
7	7.405	2.163	79.239	9.899	1.294
8	7.395	2.160	79.108	10.024	1.313
9	7.385	2.216	79.050	10.016	1.333
10	7.372	2.213	78.906	10.025	1.485
Variance Decomposition of RTGR:					
1	5.518	0.034	2.269	92.179	0.000
2	9.076	0.553	2.554	87.804	0.014
3	9.725	1.548	2.563	86.106	0.058
4	9.514	2.432	2.551	84.229	1.273
5	9.645	2.499	2.559	83.854	1.443
6	9.656	2.563	2.732	83.605	1.444
7	9.684	2.565	2.736	83.390	1.625
8	9.702	2.589	2.730	83.257	1.722
9	9.726	2.587	2.733	83.227	1.726
10	9.723	2.589	2.732	83.184	1.773
Variance Decomposition of RIR:					
1	0.452	0.345	0.079	0.070	99.053
2	0.582	0.273	0.539	0.298	98.308
3	1.256	0.286	0.493	0.278	97.686
4	1.656	0.303	0.488	0.502	97.051
5	1.719	0.300	0.484	0.948	96.549
6	1.619	0.282	0.573	0.955	96.571
7	1.623	0.266	0.537	0.884	96.690
8	1.770	0.267	0.534	0.879	96.550
9	1.834	0.267	0.547	0.919	96.433
10	1.836	0.271	0.551	0.964	96.378

Cholesky Ordering: REUBT REEXCO2 R4 RTGR RIR

Period	REUBT	REEXCO2	R4	RTGR	RIR
Variance Decomposition of REUBT:					
1	100.000	0.000	0.000	0.000	0.000
2	96.393	0.298	2.154	1.150	0.005
3	95.123	0.314	3.428	1.130	0.005
4	94.637	0.365	3.397	1.578	0.023
5	92.727	1.945	3.401	1.558	0.369
6	92.573	2.080	3.395	1.555	0.397
7	92.505	2.119	3.396	1.575	0.406
8	92.407	2.146	3.420	1.613	0.414
9	92.374	2.148	3.417	1.632	0.429
10	92.357	2.148	3.422	1.631	0.442
Variance Decomposition of REEXCO2:					
1	0.950	99.050	0.000	0.000	0.000
2	1.539	97.973	0.155	0.001	0.332
3	6.703	92.634	0.323	0.017	0.322
4	6.626	90.742	0.997	1.002	0.633
5	10.351	86.759	1.153	1.094	0.644
6	10.345	86.689	1.210	1.102	0.654
7	10.321	86.437	1.336	1.134	0.772
8	10.325	86.332	1.379	1.148	0.816
9	10.324	86.316	1.382	1.155	0.822
10	10.320	86.289	1.382	1.155	0.853
Variance Decomposition of R4:					
1	0.921	0.202	98.877	0.000	0.000
2	1.006	0.231	98.159	0.543	0.061
3	1.123	0.287	97.125	1.386	0.079
4	1.450	1.454	95.567	1.403	0.126
5	2.157	2.153	93.930	1.395	0.364
6	2.157	2.161	93.781	1.508	0.393
7	2.156	2.162	93.702	1.517	0.464
8	2.158	2.167	93.669	1.528	0.478
9	2.188	2.189	93.592	1.527	0.503
10	2.188	2.190	93.586	1.530	0.506
Variance Decomposition of RTGR:					
1	3.718	0.000	6.310	89.972	0.000
2	6.116	0.099	10.751	83.033	0.000
3	6.263	0.862	10.643	82.222	0.010
4	6.123	1.988	10.404	80.627	0.858
5	6.279	2.060	11.327	79.411	0.924
6	6.370	2.072	11.326	79.307	0.926
7	6.432	2.075	11.341	79.136	1.017
8	6.436	2.080	11.351	79.064	1.069
9	6.438	2.103	11.347	79.036	1.077
10	6.442	2.102	11.341	78.999	1.116
Variance Decomposition of RIR:					
1	0.305	0.414	0.383	0.076	98.822
2	0.320	0.374	0.593	0.448	98.265
3	0.928	0.395	0.543	0.460	97.674
4	1.306	0.422	0.646	0.547	97.079
5	1.434	0.411	0.629	1.030	96.497
6	1.350	0.389	0.612	1.090	96.559
7	1.347	0.377	0.596	0.999	96.681
8	1.441	0.375	0.593	0.994	96.597
9	1.530	0.375	0.608	1.024	96.463
10	1.536	0.387	0.613	1.083	96.381

Cholesky Ordering: REUBT REEXCO2 R10 RTGR RIR

Period	REUBT	REEXCO2	R10	RTGR	RIR
Variance Decomposition of REUBT:					
1	100.000	0.000	0.000	0.000	0.000
2	97.008	0.344	0.961	1.680	0.007
3	96.394	0.344	1.572	1.664	0.027
4	95.870	0.379	1.595	2.125	0.031
5	93.907	1.759	1.884	2.080	0.370
6	93.832	1.771	1.883	2.093	0.420
7	93.719	1.770	1.965	2.093	0.453
8	93.577	1.791	2.049	2.121	0.461
9	93.515	1.789	2.098	2.131	0.467
10	93.483	1.788	2.112	2.130	0.486
Variance Decomposition of REEXCO2:					
1	0.730	99.270	0.000	0.000	0.000
2	1.224	98.391	0.101	0.012	0.272
3	6.441	93.190	0.095	0.014	0.261
4	6.307	90.116	2.526	0.437	0.615
5	10.123	85.267	3.327	0.678	0.605
6	10.123	85.219	3.359	0.678	0.620
7	10.104	85.053	3.469	0.714	0.659
8	10.124	84.981	3.494	0.720	0.681
9	10.145	84.902	3.541	0.722	0.690
10	10.145	84.873	3.540	0.722	0.720
Variance Decomposition of R10:					
1	1.106	1.013	97.881	0.000	0.000
2	1.148	1.316	97.392	0.122	0.022
3	3.399	3.447	92.666	0.459	0.029
4	3.470	3.808	92.156	0.465	0.101
5	3.466	3.976	91.896	0.470	0.193
6	3.490	4.032	91.812	0.474	0.192
7	3.608	4.065	91.635	0.473	0.219
8	3.640	4.063	91.578	0.493	0.226
9	3.645	4.063	91.567	0.494	0.231
10	3.645	4.063	91.553	0.494	0.245
Variance Decomposition of RTGR:					
1	4.032	0.125	7.261	88.582	0.000
2	6.103	0.371	9.565	83.951	0.010
3	6.252	1.037	9.836	82.862	0.013
4	6.040	2.393	9.983	80.688	0.896
5	6.365	2.473	9.886	80.355	0.920
6	6.365	2.474	9.907	80.329	0.926
7	6.392	2.477	9.963	80.189	0.980
8	6.451	2.477	9.947	80.100	1.024
9	6.450	2.480	9.966	80.073	1.032
10	6.449	2.480	9.965	80.056	1.049
Variance Decomposition of RIR:					
1	0.495	0.445	0.011	0.075	98.974
2	0.526	0.430	0.291	0.160	98.593
3	1.113	0.432	0.294	0.159	98.002
4	1.414	0.470	0.290	0.206	97.621
5	1.540	0.458	0.287	0.603	97.112
6	1.447	0.446	0.368	0.715	97.023
7	1.416	0.413	0.379	0.669	97.123
8	1.470	0.413	0.380	0.666	97.071
9	1.532	0.413	0.381	0.689	96.985
10	1.532	0.422	0.385	0.737	96.924

Cholesky Ordering: REUBT REEXCO2 R12 RTGR RIR

Period	REUBT	REEXCO2	R12	RTGR	RIR
Variance Decomposition of REUBT:					
1	100.000	0.000	0.000	0.000	0.000
2	95.767	0.228	2.645	1.330	0.030
3	95.713	0.229	2.641	1.352	0.066
4	95.165	0.276	2.692	1.801	0.067
5	93.455	1.652	2.663	1.788	0.443
6	93.404	1.666	2.659	1.786	0.485
7	93.344	1.665	2.677	1.784	0.530
8	93.249	1.682	2.719	1.815	0.535
9	93.221	1.681	2.724	1.825	0.549
10	93.195	1.681	2.737	1.824	0.563
Variance Decomposition of REEXCO2:					
1	0.666	99.334	0.000	0.000	0.000
2	0.834	98.734	0.023	0.012	0.395
3	5.835	91.929	1.795	0.067	0.375
4	5.744	89.537	3.055	0.876	0.787
5	9.331	85.542	3.334	0.984	0.808
6	9.317	85.314	3.539	0.984	0.846
7	9.363	85.141	3.562	1.023	0.911
8	9.383	85.070	3.577	1.032	0.938
9	9.422	85.023	3.575	1.039	0.941
10	9.418	84.978	3.573	1.040	0.992
Variance Decomposition of R12:					
1	0.542	3.169	96.289	0.000	0.000
2	2.043	3.437	92.708	1.754	0.057
3	2.050	3.615	90.909	2.779	0.648
4	3.031	3.589	89.755	2.909	0.717
5	3.378	3.648	89.025	3.028	0.921
6	3.416	3.636	88.921	3.021	1.006
7	3.485	3.660	88.733	3.044	1.077
8	3.487	3.662	88.698	3.044	1.109
9	3.486	3.661	88.644	3.048	1.160
10	3.492	3.661	88.619	3.048	1.180
Variance Decomposition of RTGR:					
1	2.764	0.030	2.818	94.388	0.000
2	4.821	0.187	4.178	90.812	0.003
3	5.135	0.688	4.144	90.025	0.007
4	5.015	1.852	4.058	88.292	0.782
5	5.244	1.908	4.431	87.603	0.814
6	5.268	1.907	4.433	87.578	0.814
7	5.290	1.930	4.473	87.349	0.958
8	5.346	1.928	4.468	87.263	0.995
9	5.353	1.932	4.467	87.249	0.998
10	5.352	1.932	4.469	87.229	1.017
Variance Decomposition of RIR:					
1	0.412	0.582	0.000	0.061	98.946
2	0.437	0.442	0.038	0.201	98.882
3	0.797	0.449	0.043	0.185	98.526
4	1.109	0.513	0.897	0.196	97.285
5	1.252	0.500	0.977	0.491	96.780
6	1.190	0.472	0.951	0.530	96.857
7	1.203	0.452	0.971	0.488	96.886
8	1.314	0.451	0.985	0.485	96.765
9	1.383	0.450	1.038	0.501	96.627
10	1.385	0.460	1.064	0.526	96.565

As to the individual alternate energy companies, we see that their returns are able to explain as much as technology of oil variance errors produced in its prediction, and that company's returns together with oil returns explain more of the percentage of the prediction error variance produced in explaining carbon allowances. For these, oil and allowances have more explanatory power, while company's returns followed by oil prices explain more of the variance of the prediction error for high technology index returns. The main results with respect to interest rates are the same as before.

Just looking at the solar energy producers (r27, r29 and r30) we see that the percentage of the prediction error variance of the technology returns with respect to oil decrease in favor of carbon allowances and individual company returns. Given that there is a high percentage of solar energy produced in Germany we can say that for these companies the

Table 3: Variance Decomposition (Continued)

Cholesky Ordering: REUBT REEXCO2 R15 RTGR RIR

Period	REUBT	REEXCO2	R15	RTGR	RIR
Variance Decomposition of REUBT:					
1	100.000	0.000	0.000	0.000	0.000
2	97.055	0.487	1.295	1.091	0.072
3	96.829	0.514	1.420	1.084	0.153
4	96.233	0.576	1.569	1.225	0.396
5	94.383	1.859	1.770	1.264	0.725
6	94.246	1.857	1.771	1.271	0.855
7	94.197	1.856	1.805	1.272	0.869
8	94.145	1.873	1.806	1.287	0.889
9	94.120	1.878	1.827	1.286	0.889
10	94.106	1.879	1.840	1.287	0.888
Variance Decomposition of REEXCO2:					
1	0.456	99.544	0.000	0.000	0.000
2	0.818	97.967	1.102	0.094	0.019
3	5.639	92.089	1.892	0.258	0.122
4	5.641	90.706	2.349	1.097	0.207
5	9.140	87.002	2.431	1.214	0.213
6	9.133	86.921	2.496	1.215	0.235
7	9.132	86.881	2.498	1.249	0.240
8	9.133	86.863	2.506	1.258	0.240
9	9.146	86.812	2.504	1.258	0.280
10	9.144	86.795	2.504	1.258	0.298
Variance Decomposition of R15:					
1	3.291	0.088	96.621	0.000	0.000
2	4.006	0.136	95.283	0.259	0.315
3	4.484	0.133	93.971	0.981	0.430
4	4.881	0.529	92.834	0.970	0.786
5	4.988	0.717	91.850	1.426	1.019
6	5.082	0.712	91.160	1.415	1.631
7	5.077	0.715	91.114	1.413	1.680
8	5.075	0.757	91.047	1.424	1.696
9	5.074	0.761	91.033	1.431	1.701
10	5.074	0.763	91.028	1.431	1.703
Variance Decomposition of RTGR:					
1	2.949	0.003	8.516	88.532	0.000
2	4.756	0.070	9.253	85.919	0.002
3	5.112	1.002	9.141	84.732	0.014
4	4.985	2.090	9.680	82.941	0.304
5	5.252	2.142	9.963	82.204	0.439
6	5.254	2.190	10.000	82.112	0.445
7	5.263	2.190	10.099	81.993	0.455
8	5.315	2.196	10.095	81.921	0.473
9	5.316	2.198	10.103	81.886	0.497
10	5.317	2.198	10.104	81.884	0.497
Variance Decomposition of RIR:					
1	0.420	0.042	0.877	0.098	98.562
2	0.341	0.026	0.540	0.138	98.955
3	1.530	0.040	0.567	0.304	97.560
4	1.797	0.041	0.565	0.365	97.233
5	1.874	0.057	1.576	0.683	95.810
6	2.012	0.080	2.280	0.727	94.902
7	2.053	0.124	2.268	0.761	94.794
8	2.056	0.124	2.364	0.815	94.640
9	2.071	0.125	2.397	0.815	94.592
10	2.071	0.127	2.400	0.829	94.574

Cholesky Ordering: REUBT REEXCO2 R17 RTGR RIR

Period	REUBT	REEXCO2	R17	RTGR	RIR
Variance Decomposition of REUBT:					
1	100.000	0.000	0.000	0.000	0.000
2	97.482	0.275	0.073	2.166	0.004
3	97.292	0.278	0.181	2.227	0.023
4	96.867	0.334	0.182	2.592	0.026
5	94.988	1.767	0.289	2.571	0.385
6	94.925	1.783	0.293	2.576	0.423
7	94.884	1.786	0.293	2.574	0.464
8	94.797	1.813	0.298	2.619	0.473
9	94.765	1.814	0.309	2.631	0.481
10	94.755	1.814	0.310	2.631	0.490
Variance Decomposition of REEXCO2:					
1	0.699	99.301	0.000	0.000	0.000
2	1.095	98.532	0.037	0.007	0.328
3	6.581	93.021	0.050	0.017	0.331
4	6.571	91.334	0.049	1.407	0.638
5	10.505	86.999	0.373	1.437	0.686
6	10.500	86.953	0.403	1.436	0.708
7	10.485	86.813	0.422	1.490	0.789
8	10.486	86.741	0.435	1.518	0.819
9	10.498	86.728	0.435	1.520	0.819
10	10.497	86.702	0.436	1.520	0.844
Variance Decomposition of R17:					
1	0.004	0.239	99.757	0.000	0.000
2	0.010	0.490	99.089	0.269	0.142
3	0.020	0.511	97.350	1.216	0.904
4	0.261	1.605	95.795	1.254	1.085
5	0.464	1.595	95.268	1.299	1.374
6	0.475	1.631	94.811	1.292	1.792
7	0.485	1.640	94.791	1.291	1.793
8	0.489	1.656	94.764	1.291	1.800
9	0.489	1.664	94.744	1.301	1.801
10	0.489	1.662	94.635	1.304	1.910
Variance Decomposition of RTGR:					
1	4.094	0.031	0.632	95.244	0.000
2	6.367	0.193	0.927	92.496	0.017
3	6.496	0.816	1.200	91.457	0.031
4	6.338	2.036	1.209	89.533	0.884
5	6.605	2.106	1.198	89.105	0.987
6	6.652	2.120	1.224	89.008	0.996
7	6.711	2.140	1.223	88.839	1.087
8	6.761	2.140	1.221	88.719	1.159
9	6.766	2.143	1.228	88.704	1.160
10	6.764	2.142	1.235	88.673	1.186
Variance Decomposition of RIR:					
1	0.446	0.438	0.010	0.048	99.057
2	0.484	0.395	1.834	0.106	97.180
3	1.054	0.408	2.730	0.097	95.711
4	1.403	0.430	3.024	0.146	94.997
5	1.501	0.419	2.942	0.537	94.601
6	1.424	0.406	2.876	0.757	94.537
7	1.459	0.368	3.336	0.713	94.125
8	1.534	0.368	3.377	0.708	94.013
9	1.610	0.367	3.372	0.723	93.928
10	1.610	0.371	3.393	0.781	93.845

Cholesky Ordering: REUBT REEXCO2 R20 RTGR RIR

Period	REUBT	REEXCO2	R20	RTGR	RIR
Variance Decomposition of REUBT:					
1	100.000	0.000	0.000	0.000	0.000
2	97.221	0.383	0.251	2.125	0.019
3	97.044	0.388	0.306	2.119	0.143
4	96.276	0.433	0.656	2.258	0.376
5	94.266	1.778	0.992	2.217	0.746
6	94.052	1.775	1.070	2.226	0.877
7	94.028	1.776	1.073	2.227	0.897
8	93.953	1.795	1.093	2.227	0.933
9	93.944	1.799	1.098	2.227	0.932
10	93.940	1.800	1.098	2.229	0.932
Variance Decomposition of REEXCO2:					
1	0.562	99.438	0.000	0.000	0.000
2	0.968	99.014	0.012	0.005	0.000
3	5.884	94.021	0.031	0.008	0.056
4	5.910	92.622	0.035	1.302	0.131
5	9.361	89.141	0.037	1.323	0.137
6	9.358	89.117	0.058	1.327	0.140
7	9.354	89.058	0.064	1.379	0.145
8	9.361	89.001	0.093	1.392	0.153
9	9.368	88.929	0.109	1.394	0.201
10	9.366	88.917	0.114	1.394	0.209
Variance Decomposition of R20:					
1	0.399	0.505	99.096	0.000	0.000
2	0.435	0.480	98.568	0.016	0.501
3	0.570	0.492	98.374	0.068	0.497
4	0.696	0.488	97.845	0.477	0.493
5	0.692	0.480	97.792	0.490	0.547
6	0.692	0.479	97.753	0.501	0.575
7	0.700	0.490	97.676	0.501	0.633
8	0.700	0.495	97.666	0.508	0.632
9	0.703	0.495	97.660	0.509	0.634
10	0.703	0.495	97.659	0.509	0.634
Variance Decomposition of RTGR:					
1	3.608	0.002	0.569	95.821	0.000
2	5.414	0.108	0.938	93.491	0.048
3	5.730	0.815	0.972	92.433	0.049
4	5.654	2.048	1.205	90.841	0.252
5	5.891	2.098	1.216	90.431	0.365
6	5.941	2.110	1.216	90.363	0.371
7	5.959	2.122	1.216	90.327	0.376
8	5.994	2.121	1.235	90.272	0.377
9	6.001	2.126	1.242	90.254	0.377
10	6.001	2.127	1.244	90.250	0.378
Variance Decomposition of RIR:					
1	0.264	0.182	0.003	0.002	99.549
2	0.268	0.113	0.069	0.145	99.405
3	1.391	0.112	0.075	0.461	97.962
4	1.686	0.113	0.076	0.488	97.638
5	1.779	0.114	0.106	1.184	96.817
6	1.883	0.150	0.107	1.467	96.393
7	1.889	0.207	0.128	1.491	96.286
8	1.927	0.209	0.130	1.507	96.227
9	1.949	0.209	0.130	1.507	96.204
10	1.950	0.211	0.132	1.518	96.189

Cholesky Ordering: REUBT REEXCO2 R27 RTGR RIR

Period	REUBT	REEXCO2	R27	RTGR	RIR
Variance Decomposition of REUBT:					
1	100.000	0.000	0.000	0.000	0.000
2	97.510	1.044	0.556	0.880	0.010
3	97.006	1.038	0.884	0.874	0.198
4	96.917	1.039	0.901	0.877	0.266
5	96.914	1.041	0.901	0.877	0.266
6	96.908	1.041	0.901	0.877	0.272
7	96.905	1.041	0.901	0.877	0.275
8	96.905	1.041	0.901	0.877	0.276
9	96.905	1.041	0.901	0.877	0.276
10	96.905	1.041	0.901	0.877	0.276
Variance Decomposition of REEXCO2:					
1	0.451	99.549	0.000	0.000	0.000
2	1.183	97.423	1.286	0.096	0.012
3	6.451	92.056	1.279	0.201	0.013
4	6.451	91.936	1.288	0.303	0.022
5	6.449	91.883	1.310	0.306	0.052
6	6.449	91.878	1.311	0.306	0.056
7	6.450	91.878	1.311	0.306	0.056
8	6.450	91.877	1.311	0.306	0.057
9	6.450	91.877	1.311	0.306	0.057
10	6.450	91.877	1.311	0.306	0.057
Variance Decomposition of R27:					
1	2.840	0.008	97.152	0.000	0.000
2	3.431	0.059	96.069	0.364	0.077
3	4.075	0.170	95.119	0.545	0.092
4	4.094	0.178	95.053	0.561	0.114
5	4.117	0.180	95.029	0.561	0.114
6	4.117	0.180	95.027	0.561	0.115
7	4.117	0.180	95.027	0.561	0.115
8	4.117	0.180	95.027	0.561	0.115
9	4.118	0.180	95.027	0.561	0.115
10	4.118	0.180	95.027	0.561	0.115
Variance Decomposition of RTGR:					
1	3.167	0.011	5.237	91.586	0.000
2	4.920	0.150	6.392	88.491	0.047
3	5.144	0.955	6.350	87.456	0.096
4	5.232	0.954	6.346	87.357	0.112
5	5.306	0.953	6.345	87.284	0.112
6	5.306	0.953	6.345	87.283	0.112
7	5.306	0.953	6.345	87.283	0.112
8	5.306	0.953	6.345	87.283	0.112
9	5.306	0.953	6.345	87.283	0.112
10	5.306	0.953	6.345	87.283	0.112
Variance Decomposition of RIR:					
1	0.168	0.190	0.914	0.000	98.728
2	0.279	0.135	1.430	0.091	98.065
3	1.417	0.136	2.091	0.195	96.162
4	1.634	0.139	2.096	0.199	95.932
5	1.628	0.140	2.084	0.201	95.947
6	1.670	0.140	2.094	0.204	95.892
7	1.677	0.140	2.095	0.204	95.884
8	1.676	0.140	2.095	0.204	95.885
9	1.677	0.140	2.095	0.204	95.883
10	1.678	0.140	2.095	0.204	95.883

Cholesky Ordering: REUBT REEXCO2 R29 RTGR RIR

Period	REUBT	REEXCO2	R29	RTGR	RIR
Variance Decomposition of REUBT:					
1	100.000	0.000	0.000	0.000	0.000
2	97.335	0.450	0.079	2.121	0.015
3	97.125	0.457	0.151	2.128	0.139
4	96.459	0.488	0.419	2.311	0.324
5	94.619	1.806	0.582	2.264	0.729
6	94.493	1.804	0.607	2.267	0.828
7	94.467	1.804	0.609	2.276	0.846
8	94.396	1.815	0.614	2.299	0.876
9	94.393	1.818	0.615	2.298	0.876
10	94.386	1.820	0.616	2.301	0.876
Variance Decomposition of REEXCO2:					
1	0.639	99.361	0.000	0.000	0.000
2	1.090	98.892	0.015	0.001	0.002
3	6.150	93.624	0.175	0.002	0.049
4	6.174	92.201	0.307	1.199	0.119
5	9.667	88.695	0.307	1.207	0.124
6	9.666	88.659	0.336	1.210	0.130
7	9.656	88.588	0.378	1.245	0.132
8	9.665	88.555	0.378	1.262	0.139
9	9.670	88.498	0.381	1.264	0.186
10	9.669	88.490	0.382	1.265	0.193
Variance Decomposition of R29:					
1	0.001	0.059	99.940	0.000	0.000
2	0.005	0.051	99.896	0.030	0.019
3	0.345	0.050	98.709	0.849	0.047
4	0.338	0.096	95.985	3.487	0.094
5	0.479	0.096	95.365	3.890	0.171
6	0.480	0.096	95.218	3.879	0.327
7	0.480	0.164	95.091	3.898	0.366
8	0.482	0.179	95.056	3.899	0.383
9	0.482	0.184	95.021	3.919	0.394
10	0.483	0.187	95.017	3.919	0.394
Variance Decomposition of RTGR:					
1	3.224	0.002	1.329	95.445	0.000
2	5.019	0.113	1.791	93.056	0.020
3	5.363	0.770	2.161	91.684	0.022
4	5.282	1.996	2.177	90.293	0.251
5	5.525	2.043	2.192	89.861	0.379
6	5.616	2.061	2.189	89.748	0.386
7	5.655	2.070	2.188	89.683	0.404
8	5.704	2.070	2.186	89.635	0.404
9	5.709	2.074	2.187	89.627	0.404
10	5.709	2.074	2.187	89.623	0.407
Variance Decomposition of RIR:					
1	0.237	0.193	0.015	0.020	99.535
2	0.276	0.119	0.555	0.275	98.776
3	1.455	0.117	0.929	0.666	96.832
4	1.742	0.117	0.949	0.693	96.500
5	1.840	0.116	0.940	1.433	95.671
6	2.005	0.160	0.941	1.659	95.235
7	2.023	0.225	0.939	1.670	95.143
8	2.061	0.226	0.940	1.702	95.071
9	2.089	0.226	0.943	1.703	95.039
10	2.089	0.230	0.945	1.716	95.020

Cholesky Ordering: REUBT REEXCO2 R30 RTGR RIR

Period	REUBT	REEXCO2	R30	RTGR	RIR
Variance Decomposition of REUBT:					
1	100.000	0.000	0.000	0.000	0.000
2	97.494	0.465	0.528	1.480	0.032
3	97.059	0.474	0.848	1.472	0.147
4	96.531	0.524	0.973	1.624	0.347
5	94.858	1.813	0.997	1.606	0.726
6	94.753	1.813	0.996	1.620	0.818
7	94.662	1.813	1.065	1.625	0.835
8	94.572	1.826	1.101	1.631	0.869
9	94.559	1.832	1.108	1.632	0.869
10	94.550	1.835	1.108	1.638	0.869
Variance Decomposition of REEXCO2:					
1	0.538	99.462	0.000	0.000	0.000
2	1.035	98.653	0.294	0.016	0.003
3	5.750	93.463	0.664	0.065	0.059
4	5.725	91.774	1.546	0.803	0.151
5	9.233	87.755	1.900	0.952	0.160
6	9.233	87.729	1.905	0.952	0.181
7	9.232	87.704	1.917	0.963	0.184
8	9.230	87.646	1.963	0.973	0.188
9	9.241	87.586	1.962	0.972	0.239
10	9.241	87.579	1.963	0.972	0.245
Variance Decomposition of R30:					
1	3.245	0.234	96.520	0.000	0.000
2	3.482	0.340	95.948	0.188	0.042
3	3.928	0.511	95.198	0.278	0.085
4	4.110	0.864	94.289	0.503	0.235
5	4.256	0.879	92.836	1.800	0.229
6	4.276	0.919	92.750	1.802	0.252
7	4.303	0.920	92.699	1.815	0.263
8	4.299	0.965	92.645	1.814	0.277
9	4.298	0.971	92.616	1.839	0.277
10	4.297	0.971	92.611	1.840	0.282
Variance Decomposition of RTGR:					
1	3.069	0.024	5.572	91.335	0.000
2	4.694	0.114	6.741	88.450	0.000
3	5.030	0.986	6.754	87.228	0.002
4	4.882	2.217	7.925	84.714	0.262
5	5.170	2.251	7.872	84.326	0.381
6	5.194	2.307	7.873	84.219	0.405
7	5.221	2.309	7.927	84.121	0.422
8	5.247	2.310	7.938	84.079	0.425
9	5.248	2.314	7.942	84.069	0.427
10	5.250	2.314	7.942	84.066	0.427
Variance Decomposition of RIR:					
1	0.354	0.173	0.364	0.003	99.105
2	0.354	0.108	0.376	0.223	98.939
3	1.518	0.107	1.103	0.514	96.757
4	1.789	0.108	1.252	0.535	96.317
5	1.880	0.108	1.396	1.401	95.215
6	1.953	0.144	1.492	1.850	94.560
7	1.946	0.224	1.484	1.921	94.426
8	1.989	0.235	1.482	1.980	94.314
9	2.009	0.236	1.482	2.002	94.271
10	2.010	0.239	1.482	2.003	94.265

Cholesky Ordering: REUBT REEXCO2 R31 RTGR RIR

Period	REUBT	REEXCO2	R31	RTGR	RIR
Variance Decomposition of REUBT:					
1	100.000	0.000	0.000	0.000	0.000
2	98.207	0.165	0.035	1.583	0.010
3	97.696	0.184	0.350	1.760	0.010
4	96.720	0.224	0.833	2.207	0.015
5	94.194	1.670	1.442	2.315	0.379
6	94.111	1.688	1.441	2.354	0.406
7	94.077	1.693	1.451	2.352	0.427
8	94.060	1.695	1.452	2.367	0.427
9	93.964	1.701	1.468	2.381	0.486
10	93.923	1.704	1.468	2.382	0.524
Variance Decomposition of REEXCO2:					
1	0.906	99.094	0.000	0.000	0.000
2	1.230	98.482	0.063	0.046	0.180
3	6.776	92.498	0.382	0.111	0.233
4	6.835	91.040	0.712	0.678	0.734
5	10.507	84.509	3.354	0.945	0.685
6	10.504	84.449	3.391	0.957	0.699
7	10.488	84.331	3.445	0.984	0.752
8	10.532	84.221	3.448	1.001	0.799
9	10.546	84.199	3.446	1.009	0.800
10	10.545	84.194	3.446	1.010	0.806
Variance Decomposition of R31:					
1	0.022	0.292	99.685	0.000	0.000
2	0.201	0.549	97.706	0.877	0.667
3	0.202	0.610	96.482	2.027	0.680
4	0.541	1.539	95.223	1.992	0.704
5	0.535	1.704	94.251	2.147	1.364
6	0.692	1.706	93.399	2.127	2.076
7	0.777	1.704	93.024	2.121	2.373
8	0.816	1.718	92.969	2.124	2.373
9	0.822	1.721	92.937	2.141	2.379
10	0.821	1.719	92.848	2.143	2.468
Variance Decomposition of RTGR:					
1	4.523	0.125	3.890	91.462	0.000
2	6.558	0.245	7.486	85.662	0.050
3	6.652	0.818	7.773	84.614	0.142
4	6.413	2.023	8.529	82.178	0.858
5	6.720	2.083	8.414	81.842	0.942
6	6.789	2.150	8.405	81.708	0.948
7	6.864	2.146	8.421	81.580	0.989
8	6.936	2.148	8.430	81.401	1.085
9	6.943	2.147	8.436	81.378	1.096
10	6.941	2.147	8.433	81.350	1.129
Variance Decomposition of RIR:					
1	0.393	0.398	1.309	0.051	97.850
2	0.418	0.394	2.086	0.428	96.673
3	1.001	0.405	2.146	0.439	96.009
4	1.327	0.438	2.109	0.495	95.631
5	1.434	0.428	2.077	0.873	95.189
6	1.348	0.426	1.996	0.887	95.343
7	1.335	0.394	1.915	0.810	95.545
8	1.408	0.393	1.907	0.808	95.483
9	1.476	0.392	1.905	0.832	95.395
10	1.478	0.401	1.902	0.875	95.344

investments performed justify more the existent relationship between oil, technology, allowances and returns.

Once again, the impact of the interest rate is not relevant. Still, oil returns are more able to explain the prediction error variance produced in the estimate of carbon allowances, results being mixed with respect to companies when we consider the explanatory capacity of oil and technology over the variance prediction error of company's stock returns.

C. Impulse Response Results

We see that the renewables index impact leads to a positive and significant answer of oil prices, while a technology impact entails a positive and significant answer of oil prices and of the rDAX index. There is still no significant evidence of the interest rate over all the other variables. With respect to the oil return shock we may say it is positive and significant in the short run over the renewables index being negative in the technology case. However, these effects fade out from week six onward.

In the case of individual company's returns, and with respect to the biogas plants constructer r4, we only find evidence of positive and significant shocks of stock returns over oil, of technology over oil and of technology over oil with a two weeks lag. These shocks are significant and negative in the case of stock returns over technology and of oil over high technology returns. For the bioethanol producer r10 oil reacts positively to technology, carbon allowances react positively with a one week lag to oil and that technology reacts negatively and significantly to both oil returns and to the stock return of that company.

When we consider the fuel cell producer r12 we see that our main conclusions remain practically unchanged. That is to say that oil reacts positively and with statistical significance to stock returns and to technology in the very short run, which is to say one week. Still carbon allowances returns only react positively to oil price shocks with a two week lag and it is also evident once more the significant and negative impact of oil and company stock returns over the technology index, whose effects tend to die out after 6 weeks.

We now focus our analysis on the solar energy companies - r27, r29 and r30. These represent most of the total renewables production. Still, we are unable to establish a general patterns. We may argue that oil returns are now positively and with statistical significance impacted by carbon allowances, company stock returns and by technology. As such, the effect of higher oil prices and the relationship discussed previously between oil, carbon allowances and technology is more evident in the solar energy companies.

Moreover we also see that in the case of solar producers' carbon allowances react in a negative and significant way in the short run to the company returns. But although the first impact is negative, at the two week lag, carbon allowances returns suffer positive shocks from both oil returns and individual companies stocks thus showing that according to the initial predictions when oil price increase in the market, the tendency is for the substitution of conventional energy sources by renewables. This is especially evident for company r27 and r30. As such, higher oil prices contribute to the development of the renewables sector and the fact that carbon emission are priced in the market encourages investments in clean energy firms when we consider the individual company level. This is true only when the weight of these same companies is high enough in the total amount of renewable energy produced.

IV. Conclusions

With respect to previous results in the literature and our initial predictions, we should expect a positive impact of technology over alternate company's returns. However, our empirical estimates for ten renewable energy firms listed in the German stock market, do not allow us to say that investors see these two assets in the market as parallel in general terms. The initial effect of stock prices of clean energy companies to shocks of prices of oil-producing companies is negative instead of positive. When positive considering a three weeks delay, they are not statistically significant. Finally, when we are considering individual clean energy company's returns, all our results suggest that the interest rate is irrelevant.

For the sake of robustness, we have performed a lot more estimations always using the VAR methodology changing variables ordering and by reducing the number of variables in our VAR. The main results remained unchanged. Yet, there are still some issues that deserve a more deeply understanding and maybe using a panel VAR would help us sharpen our results and would allow us to take a deeper look into the relationship between individual company's stock returns, oil, carbon prices, technology and the interest rate.

References

[1] T. Appenzeller, "The end of cheap oil". National Geographic, 205, 6, 82-109, 2004.

[2] P. Sadorsky, "Correlations and volatility spillovers between oil prices and the stock prices of clean energy and technology companies". Energy Economics, 34, 1, 248-255, 2012.

[3] S. Kumar, S. Managi, and A. Matsuda, "Stock prices of clean energy firms, oil and carbon markets: A vector autoregressive analysis". Energy Economics, 34, 1, 215-226, 2012.

[4] S. Managi, and T. Okimoto, "Does the price of oil interact with clean energy prices in the stock market?" Japan and the World Economy, 27, 1-9, 2013.

[5] X. Wen, Y. Guo, Y.Wei, and D. Huang, "How do the stock price of new energy and fossil fuel companies correlate? Evidence from China". Energy Economics, 41, 63-75, 2014.

[6] I. Henriques, and P. Sadorsky, "Oil prices and the stock prices of alternative energy companies". Energy Economics, 30, 998-1010, 2008.

[7] P.K. Narayan, and S.S. Sharma, "New evidence on oil price and firm returns". Journal of Banking & Finance, 35, 12, 3253-3262, 2011.

[8] Climate Action Network, The Climate Change Performance Index – Results 2013. Brussels, 2014.