VOLATILITY OF EUA PRICES AND IT'S CONNECTION WITH THE PRICE OF FOSSIL FUELS AND ELECTRICITY*

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Abstract: *Prices of electricity, oil, and gas are analyzed by terms of statistical distribution of price change and volatility of price change. The best time window was determined to determine signal of price change in such manner that the change of one parameter (i.e. price) precedes the change of the other with the expected time delay. Student's distribution has shown good matching with price changes. EUA price is shows great variations, and strongly depends on the period. Back-loading of EUA prices issued by European Commission caused extreme drift in price making prediction of feasibility of long-term investments in Carbon Capture (Utilization) And Storage extremely unreliable.*

Keywords: *energy price volatility, EU ETS, EUA prices, CCS, long-term investments, oil and gas industry.*

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1. INTRODUCTION

Energy industry has a great impact on other industries. In the case of hydrocarbon production, namely natural gas and oil, the effect of price shocks is widely examined (Kim and Loungani 1992, Finn 2006), where demand for goods and services that are affected by the price of energy, and which are energy-intensive is usually reduced when energy (primarily oil) price shock occurs (Kilian 2009). The fact that energy price is heavily affected by structural breaks in the relationship between oil price and other economic parameters (Kilian and Vigfusson 2011, Ewing and Malik 2005) makes the assessments of risk in the case of any technology that is related to oil and gas industry. In this work, the hydrocarbon prices and electricity price were examined to detect the fluctuations on energy market price that might discourage or motivate the investments in CO_2 capture, transport and sequestration (storage, CCS). The main driver for CCS technologies in EU is European Emissions Trading System (EU ETS), and the important players in technology implementation must be Oil and Gas companies, due to its long-lasting experience in oil and gas reservoir research, production and management of such systems. In other words - technology exists, and is already implemented in some parts of the world (Godec et al. 2011, Wright et al. 2009, Leung et al. 2014)using it to produce additional oil. This option, called CO2enhanced oil recovery (CO2-EOR, but in EU it still seems to be too uncertain to invest into CO_2 storage.

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Eller et al. (2011) indicated that Oil and Gas companies often experience pressures that are affecting the investment strategies, like non-commercial government objectives (pronounced in the case of national oil companies). Their conclusion is that, if political objectives will overtake the control over the oil and gas industry, the production will decrease directly affecting the process.

Hartley and Medlock (2013) analyzed the revenue efficiency of national and partially privatized oil companies and shareholder owned oil companies. They emphasized that national companies, i.e. national owned companies are featured with overemployment and reduced productivity. However, they also found unidentified inefficiency sources. They found that the efficiency of merging firms did not raise, as it is expected from theory. They confirmed that is to expect that the oil and gas developments will be governed by political objectives in mind, because the national oil companies control more oil and gas resources.

2. IMPLEMENTATION OF CCS TECHNOLOGIES AND THE PROBLEM STATEMENT

The intentions to control CO_2 emissions in EU was followed by introduction of the European Union Emissions Trading System (EU ETS). It is the largest emissions allowance market. EU Allowances (EUA) can be traded and form the uniform CO_2 price in EU.

The EU ETS can include about 50 percent of CO_2 emissions from the power sector and other energy-intensive industries, and should have the following features:

- EUAs are allocated for free,
- EUAs can be auctioned,
- Emitters are encouraged to lower the reduction costs below the EUA price,
- Heavy GHG emitters can buy EUAs and postpone the CO_2 reduction,
- Buyers and sellers at EU ETS should be allowed to trade directly (without brokers) through exchanges.

Three periods of EU ETS were planned:

- First phase (2005-2007). This phase ended with price collapse because of over-allocation, but it is considered as testing phase.
- Second phase. This phase coincides with the Kyoto Protocol commitment period of 2008-2012. National allocation plans overcome over-allocation issues but determine allocation cap on the EU level. The market volume traded increased several times and market liquidity increased.
- Third phase is ongoing and active from 2013-2020.

Tendency to relate the emission costs with number of allowances has not resulted with significant success, and energy price or widely used economic indicators are not effective for prediction of EUA price movements. Structural break in allowance price was detected in first periods (Hintermann 2010).

The motivation for the analysis in this work came out from several facts:

- The investments in oil and gas industry, i.e. exploration and production of oil and gas are intensive;
- The investment return period is measured in years, and often in in more than ten years;

- Production lifetime of an oil field (and often of a natural gas field) is usually several decades. In other words, oil fields produce long time after research-team (along with all other expert and management teams) is retired. This is especially important because the credits for a profitable project are not given to specialists who developed them;
- Carbon price is not at levels that encourage CCS investments. Moreover, the trust in the trading system is yet to be built, because it has been discredited with incident such as registry phishing and value-added tax frauds (Dhamija et al. 2018);
- Oil and gas companies are not prone to subsidies, because they often constitute short-term benefits;
- CO_2 underground storage by itself requires technologies known to oil and gas industry. However, the payback period is very uncertain because of several abovementioned facts.

As the long-term price predictions are impossible, in this work only the comparison of simple statistical parameters is given.

3. THE COMPARISON OF EU ETS PRICES AND COAL, OIL AND NATURAL GAS PRICES

The summary of EUA prices in third EU ETS period does not indicate any direct correlation with coal, oil or natural gas prices (Figure 1). Electricity prices heavily depend on demand, which is very unpredictable. They show slight positive drift in last six years. Some similarities in overall drift can be observed qualitatively for EUA prices, but only until 2018. Next step of the analysis was to determine monthly price differences (variations of average monthly prices, Figure 2). Because of nature of each parameter, values are normalized (Figure 3):

$$price_{normalized} = (price - price_{min}) / (price_{max} - price_{min}) \quad (1)$$

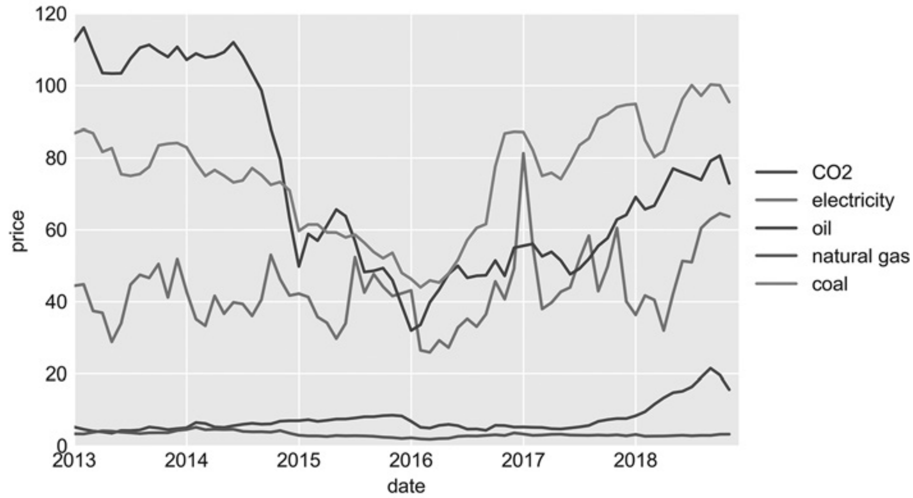

Figure 1. Energy and EUA prices
(CO2 - eur/t, Electricity - eur/MWh, oil - $/bbl, Gas - $/btu, Coal $/t)

Normalized price changes are taking into account the maximum and minimum price within the observed period (year 2013 to Nov 2018). If the period is representative for all observed parameters, it will give a proper insight into *relative magnitude* of price change (Figure 4). At this moment, the change of natural gas price can be connected with the change of EUA price, as the standard deviation *relative magnitude* of EUA price changes (EUA RMPC, that is standard deviation of normalized prices changes) decreased (or increased) every year when natural gas RMPC decreased (or increased).

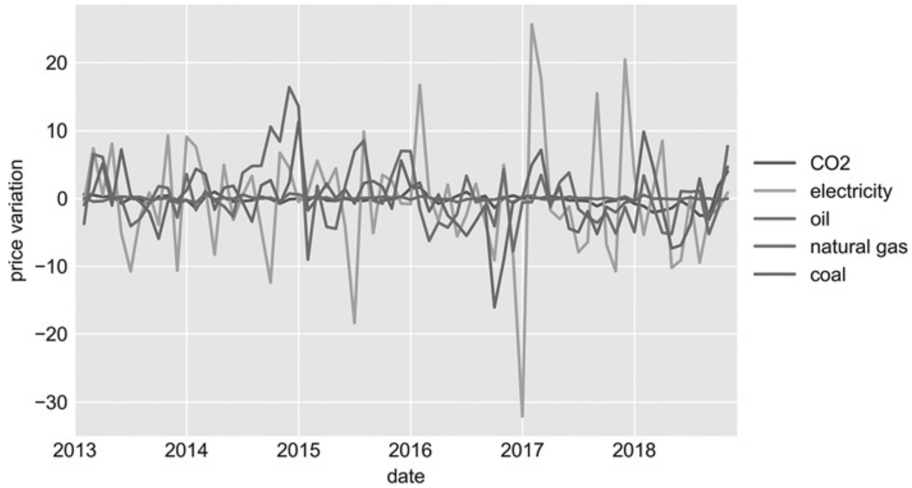

Figure 2. Relative change of prices

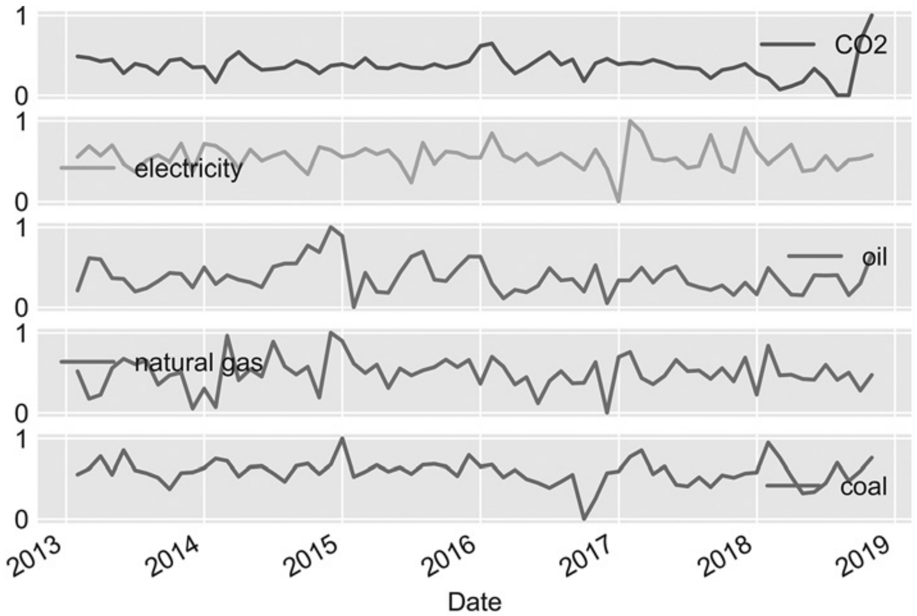

Figure 3. Relative change of normalized prices

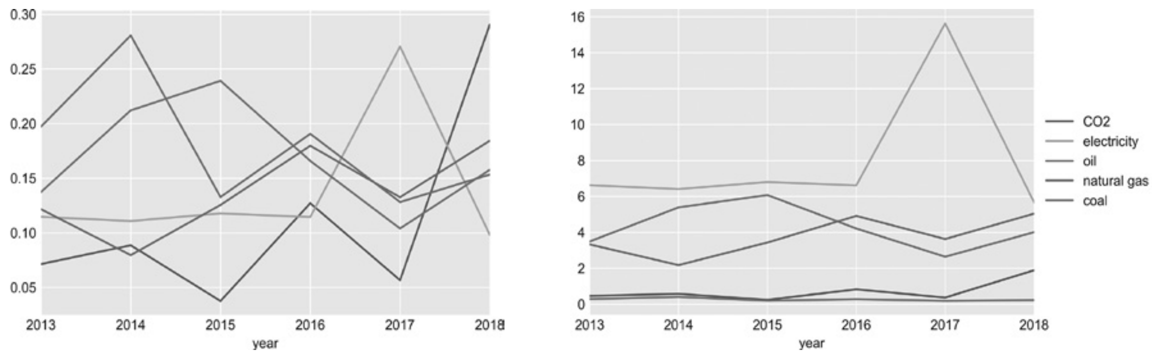

Figure 4. Standard deviation of normalized prices changes (left)
and of absolute prices changes (right).

Next step of the analysis was focused on statistical distribution testing of monthly price changes. As the process was conducted automatically (by coding the function for distribution testing in Python programming language, and with *scipy.stats* library, www. SciPy.org 2019), large number of distributions was tested. Distributions are evaluated by finding the best goodness of fit by Kolmogorov-Smirnov (K-S) test, i.e. the test statistic (D, supremum between CDF's of two samples) and p-values (the probability that the D statistic value will be larger than observed). Because every distribution testing method has its disadvantages, distributions are also checked visually by plotting (Figure 5). Top 3 distributions for every parameter are listed in Table 1.

Table 1. Summary of best fitted distributions

	distribution	D	p
CO_2			
	johnsonsu	0.071523	0.866390
	t	0.074513	0.831842
	laplace	0.082111	0.737905
Electric power			
	johnsonsu	0.040681	0.999825
	t	0.049481	0.995472
	fisk	0.051749	0.991975
Oil			
	johnsonsu	0.055165	0.983415
	exponweib	0.056375	0.979249
	johnsonsb	0.058606	0.969794
natural gas			
	hypsecant	0.041061	0.999789
	johnsonsu	0.042821	0.999532
	t	0.045671	0.998596
coal			
	johnsonsu	0.056213	0.979844
	t	0.058458	0.970495
	hypsecant	0.065114	0.927959

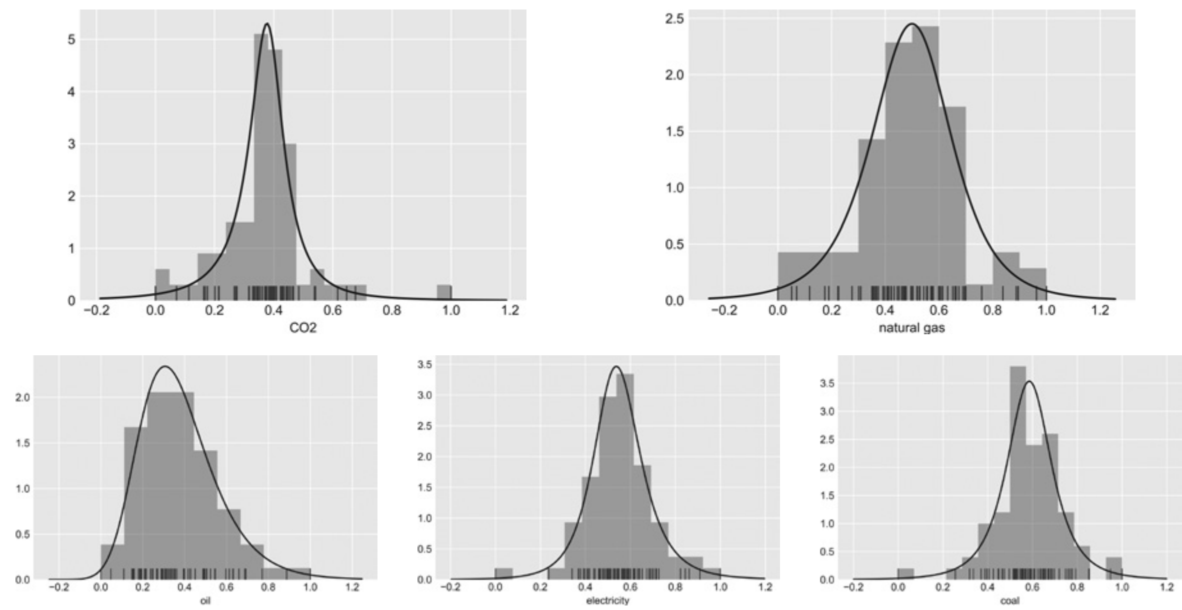

Figure 5. Normalized price changes and their fit to Johnson SU statistical distribution (first row: left - CO_2, right - natural gas; second row: oil, electricity and coal from left to right, respectively)

Johnson SU distribution (Johnson 1949) shows in most cases the best fit. However, it must be mentioned that the distributions might be different if different time window (e.g. a weekly or quarterly) for the analysis of price changes was used. Extensive analyses were performed for purposes of ESCOM project; however, the distribution testing only gives insight to more detailed features of price changes and volatility in general, but cannot be used as a tool for predictions of risk of long-term investments such as CCS.

4. CONCLUSIONS

Policies should motivate CCS through the early deployment phase which must include the integration of new technologies and mechanisms for all segments of CCS. Oil and gas companies can immediately implement many of required technologies, but the changes of business policy in oil and gas companies are required.

Technological innovation in efficiency of carbon capture and CO_2 utilization technologies must be encouraged. For oil and gas companies - this leads to enhanced oil recovery methods (EOR) that are proven as successful both for oil recovery and CO_2 storage (injected CO_2 retention). Such technologies need improved quality of CO_2 transport system, and research network, which might include merging of departments between different companies and cooperation with research institutions. However, the analyses of such merging already showed decrease of efficiency, and CCS technologies will be possible only with increased efficiency.

In this work, based on statistical analysis following conclusions are drawn:

- CO_2 price and natural gas price have smallest standard deviations (which can be interpreted as volatility) of prices, i.e. price changes. However, CO_2 price jump in 2018, makes estimates of price changes unreliable,
- CO_2 price changes follow the natural gas changes which is notable from standard deviation of normalized prices changes,
- Electric power and natural gas monthly price changes show the best goodness of fit to Johnson SU distribution. This confirms that observation of natural gas price changes might be good indicator for assessments of EUA prices.

Generally, more data on EUA prices is needed, which means that the EU ETS market is immature and long-term investments in CCS, without big subsidies from governments, will not be attractive soon.

By summarizing, stability of natural gas prices (and natural gas seems to be the most important energy source for energy transition in EU) might accelerate the stabilization of EUA prices.

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