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CSE 140

Evaluating the Effectiveness of the European Union Emissions Trading System

This report will answer two main questions:

1) **Can the theoretical coal-to-gas switch price be translated to markets outside of Britain?** The theoretical coal-to-gas switch price is a metric developed by Stefano Clo to gauge the effectiveness of the European Union's Emissions Trading System (EU ETS). Clo's metric is computed from the spot prices of British coal and natural gas, as well as the price of CO2 emissions permits. However, Britain comprises only a small percentage of total European emissions. If Clo's conclusions are to be extrapolated to the rest of Europe, it must first be demonstrated that computations based on commodity spot prices from other parts of Europe produce similar coal-to-gas switch prices for given dates.
2) **What can the coal-to-gas switch price tell us about phase 2 of the EU ETS?** Clo's report was published in 2011 and computed the coal-to-gas switch price for phase 1 of the ETS program (2005-2008) only. The second phase concluded at the end of 2012, but the coal-to-gas switch price over that period has not yet been published. Once computed, the coal-to-gas switch price will provide a quantitative measurement of the ETS's overall effectiveness during phase 2 and a means of comparing the two phases.

Background:

The European Union Emissions Trading System (EU ETS) is the world's largest system for trading greenhouse gas emissions permits. Established in 2005, the ETS is designed to use open-market mechanisms to meet the 1997 Kyoto Protocol's emissions standards. While the ETS takes many cues from the United States' successful sulfur dioxide emissions trading program, cap and trade on the international level remains something of a grand experiment. The scope of the system is far greater than any other system of its kind—more than 11,000 installations across 31 member nations participate. Since environmental regulation inevitably imposes some economic cost on polluters, each member nation has an interest in protecting its own economy by either minimizing its exposure to the ETS or by lobbying for a less stringent cap on emissions. Meanwhile, the European Commission is tasked with determining an appropriate cap level such that the Kyoto Protocol's targets are met without placing undue stress on the economies of the member states. It is important, therefore, to have a means of

quantitatively measuring the appropriateness of an emissions cap, which by extension would measure the effectiveness of the ETS.

In his 2011 book European Emissions Trading in Practice, economist Stefano Clo develops a metric by which the ETS's effectiveness can be gauged. Clo observes that many coal-burning power plants could be relatively inexpensively retrofitted to operate on natural gas. Coal is less expensive than gas, but also produces more carbon dioxide when burned. Since the total amount of CO2 that a facility can emit is determined by the number of ETS emissions permits that the facility holds, a plant that chooses to burn coal must purchase more permits than a similar gas-burning plant. All three commodities (coal, gas, and ETS permits) are traded on open markets—their prices are determined by the laws of supply and demand and therefore fluctuate regularly. Clo's metric, the theoretical coal-to-gas switch price, is meant to indicate whether or not power plants have an economic incentive to change from coal to gas at any given time. If the price of CO2 permits is greater than the coal-to-gas switch price, the ETS system is providing sufficient economic incentive to switch from coal to gas.

Dataset:

Much of the CSE work associated with this project stems from the challenge of obtaining the necessary dataset. Clo drew on financial consultancies (Point Carbon and Fortis Bank) to compile his data. Unfortunately for this project, Point Carbon's rate for access to their databases is €1400. Fortis Bank's website does not elaborate on its fee structure, but I suspect that their services are also beyond the means of an unemployed undergrad. Similar data is available from the European Energy Exchange (EEX), a German energy-trading site, but it is relatively difficult to recover and clean. For example, EEX provides historical carbon price data for seven day windows only. As an example, one such webpage can be viewed at https://www.eex.com/en/Market%20Data/Trading%20Data/Emission%20Rights/EU%20Emission%20Allowances%20%7C%20Spot/spot-eua-table/2010-01-15

I have written a program that repeatedly queries eex.com, downloads the source code, and then recovers ETS permit prices, one-month coal futures price, and natural gas prices. Additionally, the program collects USD to Euro exchange rate information from http://www.federalreserve.gov/releases/h10/hist/dat00_eu.htm

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Methodology:

The coal-to-gas switch price is relatively simple to compute.

Coal plant electricity price (€/MWh) =

coal price (€/MWh)/38% + CO2 price (€/ton CO2) * .95 (ton CO2/MWH)

Gas plant electricity price (€/MWh) =

gas price (€/MWh)/53% + CO2 price (€/ton CO2) * .45 (ton CO2/MWH)

Equating the two electricity prices and solving for CO2 price gives the theoretical coal-to-gas switch price.

Clo delivers his analysis of phase 1 in the form of two charts: one showing the coal-to-gas switch price over time, and one showing the difference between CO2 price and coal-to-gas switch price over time. Since I will be using German data, I do not expect my graphs from period 1 to be identical to Clo's. However, the general shape of the curves should be similar, and the points at which the curves cross the x-axis (the most significant points for this analysis) should be nearly identical.

Once the data has been collected and cleaned (the bulk of the work for this project) and the coal-to-gas switch price computed, the final stage of the project will be to construct a clear visualization of the data.

Results:

Can the theoretical coal-to-gas switch price be translated to markets outside of Britain?

My analysis produces an inconclusive answer to this question. Since I do not have access to Clo's data, I am judging the accuracy of my algorithm by comparing my program's output plots to the plots that Clo published in his book. If my program is confirm that the coal-to-gas switch price metric can be directly translated to markets outside of Britain, the program must produce a plot that is very similar to Clo's plot. However, while the shape of my plot is almost identical to Clo's, the scale is significantly different. I can think of several possible explanations:

1) My implementation is incorrect. I have confirmed by results by hand for several data points, which suggests that my program is doing what I expect it to do.

2) My algorithm is incorrect. I can't rule this possibility out. The math involved is very simple—nothing more sophisticated than algebra is required. However, without access to Clo's data I do not have a concrete way of confirming my calculations.
3) My data is inaccurate. This is another possibility that cannot be ruled out. I am basing my analysis on data that is collected from the internet, without the permission of the website's owner. The fact that the shape of my plot fits Clo's so tightly is reassuring and suggests that if my data is inaccurate it is at least precise. It may be that one of my variables is off by some scalar, which would cause my results to deviate from Clo's by a consistent factor.
4) The coal-to-gas switch price cannot be translated to German markets. If none of the above is true, this is the remaining possibility.

I think the only way to clear this up is to contact Stefano Clo and ask for his thoughts. I was able to find an email address for him through a quick Google search. With any luck, he will find these results interesting (worst case, he will just ignore me).

What can the coal-to-gas switch price tell us about phase 2 of the EU ETS?

The results of the first question cast serious shadows on the second. If we assume that my implementation, algorithm, and data are all correct and proceed as though the coal-to-gas switch price translates to German markets, the results of my program suggest that the European Commission's CO2 cap is too loose in ETS phase 2, just as Clo's research indicates that it was too loose in phase 1. This result is actually consistent with the qualitative analyses of several other economists. It has been widely speculated that the EC has intentionally set the cap at a level such that very little pressure is placed on businesses, with the intention of reducing pushback from lobbies, interest groups, and national governments. The cap is scheduled to tighten incrementally over the next thirty years, so the coal-to-gas-switch price may prove to be a more meaningful metric at a later date.

It is worth noting that the price of natural gas nearly doubled during the period of this analysis, while the price of coal remained fairly constant. This change in price dramatically skewed the coal-to-gas switch price for this period.

Reproducing results:

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In order to reproduce the results of this analysis, open the program reid_johnsen_1211338_EU_ETS.py in IDLE. The dataset took over an hour to download, so I have provided the complete dataset along with the program.

To test the data collection component of the program, run the function

data_collection_test([2010,2,1],[2010,5,1]) (This takes about 3 minutes on my machine)

To test the visualization of the data, run the function

plot_coal_to_gas_complete("phase2_data")

or

plot_coal_to_gas_complete("test_data")

All three functions are commented out at the end of the program. Simply un-comment the ones that you would like to test.

Collaboration: None

Reflection: I'm looking forward to continuing this project. I ended up writing more than 400 lines of code, and yet still have an inconclusive result. As a CSE exercise, I'm happy with the work that I've done (I'm especially proud of the re-factoring of the CO2 and gas price data functions), but as an economic case study it would be unsatisfying to leave the project here.