CARBON EMISSIONS

An in depth analysis of the Carbon Emissions market with a focus on its implementation to date in Europe

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1. Executive Summary

The purpose of this paper is to understand the relatively young Carbon market in the European Union. The analysis identifies the key mechanisms that allow the system to work, explores the nature of the regulatory environment, assesses the current situation, and identifies future trends that will be of importance in coming years. The paper analyzes the different control mechanisms such as CDMs, Joint Implementation and the functionality of the carbon trading market in itself. In essence these mechanisms allow the trade of carbon credits to flow and incentivize movement towards a greener world through a carrot and stick approach.

Particularly noteworthy, are the various obstacles that have been overcome to date and the ongoing consequences of a regulatory environment that falls short of expectations and prevents investor trust. Also, there is a clear concern that reducing the cap, which is currently in surplus, may hamper levels of economic growth further particularly for peripheral countries in Europe that are reliant on manufacturing and emit proportionately higher levels of carbon.

The final portion of this paper synthesizes data in an attempt to understand forces that affect prices and correlation of variables. The hypothesis is that other commodity prices and macroeconomic indicators will have strong correlation with carbon pricing. In effect, these factors have allowed us to build a functional regression model with an R squared adjusted value of 94.2%; the analysis found that Gasoline prices, Jet fuel prices, the 1 month Libor, the 3 month Libor, 3 month Euribor, 12 month Euribor, Weather, stock price of Enlay Spa and the Industrial Production Index are the best indicating variables given the data collected.
2. **Historical Overview:**

Carbon Dioxide (CO$_2$) is a gas that is released into the atmosphere by living organisms and is considered to be a building block of life; however, anthropogenic processes, particularly manufacturing which dramatically increased during the industrial revolution has severely changed atmospheric concentrations with new highs of CO$_2$ recorded. Recent recordings in Arctic regions have denoted 400 parts per million in the atmosphere (Exhibit 1); the earth has not attained such atmospheric highs for carbon dioxide prior to 800,000 years ago$^1$. Carbon Dioxide is a heat trapping gas commonly referred to as a greenhouse gas which signifies that it alters the cooling processes of the planet and seasonal temperature across the globe. These temperatures affect habitats and living conditions for organisms and threaten to endanger their existence$^1$.

In light of this, the Rio Earth Summit, held in 1992 acknowledged the international need for climate control as it became a growing concern among scientists$^2$; while the conference raised broad concerns and acknowledged the effects of other greenhouse gasses as well, this was the first step towards establishing a regulatory environment for carbon emissions which ultimately led to the establishment of a market that functions similar to the trading of other commodities.

This was then taken a step further through the establishment of the Kyoto protocol which was held in Kyoto, Japan. The Kyoto protocol of 1996 is an international treaty designed to legally bind nations to reduce emission levels of six major greenhouse gases by a target 5% benchmarked against 1990 levels over the five year period from 2008-1012. Although a total of 192 Countries have ratified the Kyoto Protocol as of November 23, 2012, only 37 industrialized countries and the EU Community are bound to the stated target (Exhibit 3). “the protocol places a heavier burden on developed nations under the principle of common, but differentiated responsibilities”$^3$ as Annex 1 or highly industrialized countries are estimated to be responsible for approximately 64% of total greenhouse gas emissions up to 1990$^4$. The implementation process was outlined in the Marrakesh Accords in 2001 and has been enforced since 2005$^3$.

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$^4"Carbon\ Market\ Overview."\ Point\ Carbon:\ Providing\ Critical\ Insights\ into\ Energy\ and\ Environmental\ Markets.\ Thomson\ Reuters,\ n.d.\ Web.\ 28\ Nov.\ 2012.\ <http://www.pointcarbon.com/productsandservices/1.266920>.
Annex 1 countries that have ratified the treaty are permitted to host emission reduction projects which are discussed further below. The protocol offers countries assistance in meeting targets through permission to use three market based mechanisms.

### 2.1 Clean Development Mechanism (CDM)

The first mechanism is known as the Clean Development Mechanism (CDM) and is defined in article twelve of the Kyoto protocol as a mechanism that allows an Annex B country to implement an emissions reduction program in a developing country. Implementing an initiative like this earns a country Certified Emission Reduction credits (CER), each worth one ton of CO2 (Exhibit 2), which can be traded or used by the country who earned it\(^5\). This is an incredibly innovative scheme, the first in the world to provide a standard emissions offsetting tool. The initiatives taken to earn these credits vary and can include helping implement solar panels in a rural area or installing wind turbines to provide power in underdeveloped countries. It pushes reducing emissions in places that would have trouble doing it on their own in order to increase emissions permits incrementally\(^5\).

A CDM project must reduce emissions additional to what would have occurred without the project, and faces firm regulations. The initiative must also go through an intensive and public registration and issuance process prior to approval by the “Designated National Authorities”\(^3\). The CDM is overseen by the CDM Executive Board and is also answerable to each and every country that has ratified the Kyoto Protocol. It has been in place since the beginning of 2006 and has overseen 1,650 projects with an anticipated net result of 2.9 billion tons of CO2 in CERs in the first commitment period (2008-2012).

As of November 23rd, 2012, 5116 CDM projects had been registered by the CDM Executive Board which will result in the total issue of 2,170,000,000 Certified Emissions Reductions until the end of 2012. With a current price of carbon of about 7 Euros this is 15,190,000,000 Euros issued just for CDMs. Of those projects: 65.15% belongs to China, 10.33% from India, 3.66% from Brazil, 2.84% from Republic of Korea and 20.86% from other countries\(^6\) (Exhibit 5).

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2.2 Joint Implementation

The second mechanism is “joint implementation,” as defined by Article six of the Kyoto protocol and allows an Annex B country to earn emissions reduction unites (ERUs) by implementing an emissions reduction/removal initiative in another Annex B country. ERUs are each equivalent to one ton of CO₂ emissions which can be counted towards meeting the country’s Kyoto target. Joint Implementation offers countries a flexible and efficient method of meeting their Kyoto emissions requirements whilst having one of the countries benefit from a transfer of technology.

A majority of the demand for Certified Emission Reduction (CER) certificates come from the European Union Emissions Trading Scheme (the biggest carbon market). Other large industrial countries either did not ratify the Kyoto Protocol like the United States or do not have the obligation to cut emissions like China and India, leaving EU as the main source of demand for CERs. As the supply of CERs grew from various CDM projects throughout the world - primarily China, India, Korea and Brazil - the market price for CERs fell from $20 to less than $5 a ton⁷. This represented a change in price of about 75% in a year. With such low CER prices, potential projects were not commercially viable. In October 2012, CER prices fell to a new low of 1.36 euros a metric ton on the London ICE Futures Europe exchange⁸.

A joint implementation project is required to cause a reduction in emissions by sources or an enhancement of removal that is in addition to what would have otherwise occurred. Once these emissions are verified, the host country may issue the appropriate quantity of ERUs. This procedure is called the “Track 1” procedure. If a host country meets a limited set of requirements, verification of reduction of emissions must be done through the “Joint Implementation Supervisory Committee (JISC)”⁹. This is known as a “Track 2” procedure; after this is completed, the appropriate amount of ERUs will be issued.

2.3 Carbon Trading

⁸ Harvey, Fiona "Global carbon trading system has 'essentially collapsed'". The Guardian. Web. 29 Nov., 2012
The third and most important mechanism marks the establishment of carbon trading as a commodity. Every country participating in the treaty is assigned a quota for each gas, expressed as Assigned Amount Units (AAUs), but they retain flexibility under a cap and trade system. In other words, countries which have a surplus are permitted to offload excess capacity to other countries which have either exceeded capacity already or forecast that they will. This is commonly referred to as the Carbon Market. However, it is not only AAUs that can be traded as countries can earn credits in order to help them meet their Kyoto Targets. These credits can be in three forms: RMUs, ERUs and CERs.

A Removal Unit or RMU may be issued on the basis of land use, change and forestry activities such as reforestation. An RMU is equivalent to one ton of CO2 emission (just like an ERU or CER) and can be traded or kept by a country depending on their emissions needs. An Emissions Reduction Unit (as mentioned above) may be earned through a joint implementation project in an Annex B country. A Certified Emissions Reduction credit can be earned through a clean development mechanism (CDM) project held in a developing country. Each of these units is transferrable from country to country and is tracked and recorded through registry systems under the Kyoto Protocol. An international log keeps track of how many credits go where and make sure the transfer of credits between countries is secure10.

3. Regulation:

With the ability to sell these units so easily, there is of course the concern of overselling; in order to make a tidy profit, a country could sell off too many of its credits and not be able to meet its target Kyoto requirements. To counterbalance this, each country is mandated to keep a reserve of ERUs, CERs, AAUs and/or RMUs in its national registry. This reserve is referred to as the “commitment period reserve,” and cannot drop below ninety percent of the country’s assigned amount or one hundred percent of five times its most recently reviewed inventory, whichever is lower11. This makes sure countries have enough credits to cover themselves before realizing an excess which they can trade away for a profit.

Despite implementation of Carbon trading since 2008, the regulatory environment is still not fully understood by firms subject to this regulation. In fact, the Financial Services Authority in the United Kingdom has taken initiative to clarify how trading takes place and to enforce the need for due diligence to investors\textsuperscript{12}. While salespeople are actively selling these credits under certified labels, these certifications are not universally recognized: “Beware that VERs [Voluntary Emission Reduction] certificates are often labelled as ‘certified’, but this certification is voluntary and involves a wide range of bodies and different quality standards that are not recognized by any UK compensation scheme.”\textsuperscript{13} Most importantly, they are not protected under the Financial Services Compensation Scheme (FSCS).

The only real way to ensure that companies follow through with expected reductions is a sanction based system. Independent government authorities compile company data and report to the European Commission annually in what is known as the compliance cycle\textsuperscript{14}. The methods of measurement are audited to ensure consistent measures and templates or guidelines are in place for industries, namely the aviation industry\textsuperscript{15}.

For the aviation industry it is outlined that airline operators must trade in one allowance for CO\textsubscript{2} emissions for flights within as well as to and from the European Union. Airlines must submit monitoring plans for emissions which will be approved and verified. Pricewaterhouse Coopers (PwC) is an active participant in these regulations and say the following on their website:

“Non-complying operators face a penalty of €100 per missing allowance on top of the obligation to procure and surrender missing allowances. They may even be banned from operating in the EU” (9). PwC is working for and with the EU Member States to develop guidance for completing Monitoring Plans which also


explains the Monitoring and Reporting Guidelines. The European Commission issued templates for such plans which Member States will have to use\(^\text{16}\).

Despite the fact that there are a number of regulations in place, it is still subject to ordinary scandals that occur in other markets due to loopholes that have been established. In March of 2011, it came to light that some governments (such as Hungary) had started recycling credits (selling used credits) for a profit. While this is not illegal (for example some Japanese companies buy these old credits to show their customer base that they are green), it is illegal if the credits end up back in the European system as they did in this case\(^\text{17}\).

Following this, the first indications of carbon credit theft came about in the form of phishing scams, with emails sent to market participants to try and get their passwords for the regulation system. Once December 2011 criminals had pilfered 28 million Euros worth of carbon credits from Romania via a cyber-robbery, causing the closure of its national registry at the same time allowances were also reported missing in Switzerland. With this, the European Commission decided to close the spot-trading market indefinitely. The entire incident severely discredited this new market which had already been deemed as one with a reputation for lax regulation or an unsafe investing environment\(^\text{16}\).

One of the major problems was the level of encryption used for the data. The system was not nearly as secure as it should have been using a fairly weak encryption level which was updated after the fiasco. The regulation of trades needs to be closely monitored as well; each trade has a serial number, but the trades happen so quickly that the trade can be long gone before they can be traced. A buyer can buy a credit from someone and not even know it was stolen until it is too late; in such scenarios it is difficult to allocate liability in this regard. "There have been warnings after warnings that regulation of the system is lackadaisical and inept" says one disillusioned broker at a big London company, who used to work in oil. "It's totally affected the


reputation. You expect it to be properly regulated but Europe seems to run it more like a church raffle than a professional commodities market.\textsuperscript{18}

Regulating this market properly and treating it as a market rather than a “church raffle,”\textsuperscript{17} is a very important issue at the moment. If people see this market isn’t being treated and regulated seriously, they will lose the will to invest in it and help it grow. Without regulation, it will be susceptible to fraud and theft as it has been in the past. This more than anything else at the moment can mean the end for the entire carbon market if left as is for much longer.

4. **Current Situation:**

Prices for Carbon AAU’s have been dropping at rapid rates due to excess supply of permits. Although commodity prices rose as high as €30 in 2008, this has now fallen to quoted rates consistently below €10 in 2012; with recent quoted prices as low as €7\textsuperscript{19}.

On one hand, this suggests that the system is working effectively and yielding desired results as companies are below expected emission level. On the other hand, this is threatening to bring green energy projects to a standstill as prices are far too low to incentivize research and development into new technologies. Furthermore, analysts allocate emission reductions to the economic crisis which has reduced demand for manufacturing To make matters worse, the EU is currently selling 300M more license to raise funding for government led energy efficient products. An investment banker Matthew Gray of Jefferies argues: “the ETS will have an accumulated surplus of 845m permits, against a planned cap that year of 1.8 billion permits”\textsuperscript{20}. However, estimates do vary and can be as high as 881 (Exhibit 4).

This has led to calls for intervention in a variety of different forms. Three different solutions have been proposed. The first strategy involves setting a price floor to ensure that firms remain motivated to reduce emission levels. Alternatively, a proposal to withhold permits and not factor them into current prices has been set forward. Finally, some have recommended reworking targets and tightening the cap for permits. Given the current climate of economic recession and slow recovery therefrom, the first option has been ratified by a committee and will


be put before parliament. However, the simplest method would be to tighten the cap, but there remain fears that this would not be well received by high emission countries such as Poland and threaten economic output levels.20

5. **The Future of Energy**

The Carbon Market isn’t working just to regulate the trade of carbon in the world, but rather to reduce it. There are various alternatives to carbon emissions referred to as Alternative energy. By 2050, experts say that one third of the world’s energy will come from renewable sources such as solar or wind. This sentiment is echoed by British Petroleum and Royal Dutch Shell, two of the largest oil companies in the world. A more optimistic prediction from the EU suggests it will account for 55%.22

Alternative Energy refers to energy sources that have no harmful effects on the environment (no release of greenhouse gasses). These are often considered to be renewable and as such are considered free energy. They all have extremely low carbon emissions outputs compared to the normal energy sources such as oil or coal. They include wind energy, solar energy, hydroelectric energy, geothermal energy and biomass energy.

5.1 **Solar Energy**

Solar energy is considered the cleanest source of energy from an environmental perspective. A 1.5 kilowatt Photovoltaic cell system will keep more than 110,000 pounds of CO\textsubscript{2} out of the air over the next 25 years- this amounts to about 55 tons of CO\textsubscript{2} or 55 carbon credits.20 Solar panels convert the movement of light molecules into energy that can be used to power a business or home. The current issue most businesses have is the initial investment cost for these cells. They are currently expensive as they are not mass produced or adopted by the masses. Despite their costs, they often come with extensive warranties, are bomb-proof and are durable. The most obvious benefit to this is there is absolutely no carbon dioxide released into the environment using this technology and after the initial cost, it provides you with free energy for

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as long as the panels last, requiring timely maintenance\textsuperscript{23} \textsuperscript{22}. Another significant drawback to solar is

### 5.2 Wind Power

Wind power is something societies have been taking advantage of for ages. Sailors who used wind to push their boats, farmers who have used windmills to grind their wheat and even homemakers who have been using wind to dry their clothes have all taken advantage of wind power. Today, companies are putting up wind turbines in as many places as they can, trying to harness the wind to power homes. It is referred to as one of the most “promising new energy sources\textsuperscript{24}”. To capture wind energy companies erect wind turbines (Exhibit 6) in fields that move when wind is present. When the turbines move, they send the mechanical energy to a motor inside them which converts the mechanical energy to electric and stores it for future use. This method also produces no greenhouse gasses and is quite sustainable over time. The biggest problem with this is that turbines are expensive and incredibly loud, causing noise pollution when in motion. This can be counteracted by putting them in unpopulated areas and creating what are known as “wind farms,” huge fields filled with turbines far away from society. This method of energy production is also said to provide free energy after creation, minus some minor maintenance costs\textsuperscript{25}.

While all of these sources of energy are currently more expensive and less efficient than carbon based ones, eventually the sanctions and limitations on carbon will get to a point where carbon permits are too expensive to buy for certain companies and as such they will pay the switching cost to jump to a renewable source of energy for at least a percentage of their production needs. Hopefully in the coming years the Kyoto protocol will help to push some companies to switch their production methods; in effect, this would reduce the significance of the carbon market despite predictions that it will be one of the widest traded commodities should the US ratify the protocol\textsuperscript{26}.


6. **Regression Analysis Factors**

As the Carbon emission market is relatively young, data for prices has been collected over the past 36 months. Since the birth of the EU-ETS, many have taken the time to write about what factors help mold the price of carbon credits from year to year. At first glance, it may seem simple; if supply is decreased, demand goes up, or if demand goes up so does price, but there are many more factors involved in determining the price of this derivative. Experts have determined that some of the determinants of price include institutional decisions, energy prices, economic/financial market shocks and weather events based on a study compiled by Julien Chevallier from the University Paris Dauphine\(^\text{27}\).

6.1 **Institutional Decisions**

The first of these factors (institutional decisions) can be described most aptly as the "emissions shortfall" factor, which is the difference between the emissions needed by either a company or a society as a whole and the given compliance within the year. The best example of this occurred during 2006 (a year after the instatement of the EU-ETS). Subsequently, this was when the first report of verified emissions was published by the EU commission after which there was a huge drop in the price of Carbon dropping it by nearly 50% within two days. The reason for this drop was that the ratio of allocated allowance of carbon to actual carbon emissions was too high, leading investors to realize that carbon was over-supplied. Since there was a high allowance to produce carbon in the EU, the value of the permits was low. Hence, it was deemed permits were not worth close to the value they were currently at and many sold them off. This surplus of permits was a problem from 2005-2007 (also known as the first phase of the EU-ETC’s program). There is no way to measure this indicator on a monthly basis in a regression for prices of carbon.

6.2 **Energy Prices**

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Another important set of factors to consider are energy prices. The carbon market is one of the newest energy markets and as such, competes with more traditional means of energy such as oil, gas and coal. Mansanet-Bataller and Alberola were the first analyses to uncover econometrically the relations between energy markets and the CO$_2$ price$^{24}$. Based on phase 1 spot and futures data, the former group of authors establishes that carbon prices in the EU ETS are linked to fossil fuel (e.g., oil, gas, coal) use.” The exact nature of the relationship between fossil fuels and carbon prices varies depending on the period under consideration and the external events occurring at the time. The demand for these fossil fuels in affected not only by their absolute price but on their relative price as well. Due to this, we must consider a company’s marginal switching cost from carbon to a fossil fuel. This switching cost factors into the price of Carbon as well as it directly affects the demand for fossil fuels$^{28}$. Hence, we collected data on crude oil prices, gasoline, jet fuel, heating oil, and propane prices over the same 36 month period to track responsiveness to energy prices.

**6.3 Temperature**

Carbon prices are also affected by unexpected changes in climate including temperature, abnormal rain and wind. For instance, colder winters increase the need for heat by using electricity (vice versa for summers). “When departing from seasonal averages, Alberola show that extreme (and essentially unanticipated) temperatures events have a statistically significant effect on carbon price changes.” Furthermore, in today’s society where alternate forms of energy (such as hydro-power, wind-power and solar power) are becoming more popular, we must consider how they generate more power during conditions that favor them. For example, if there is an extremely windy season, then wind turbines will be able to generate more power, creating more power that isn’t carbon generated to be used. Combining all of these shows how weather is an important factor to consider when evaluating the movement of the price of carbon in the market today. The only problem with this is that it has not been researched heavily enough for the EU region and as such enough data to analyze exactly how much each of these factors affects

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the price of carbon has not been collected. Running on the assumption that this does affect carbon prices, we collected weather data of mean temperatures for Brussels.

### 6.4 Economic Factors

The final factors that affect Carbon pricing are economic factors (in this case specifically microeconomic factors) and financial market indicators. “Interestingly, several studies uncover some econometric links between the carbon market and several indicators related to macroeconomic and financial markets. Oberndorfer has first tackled this issue from the angle of the stock markets. The author shows that CO2 price changes and stock returns of the most important European electricity corporations are positively related.”

This shows us (based on the studies mentioned) that as the returns of big electric corporations increase so does the price of carbon. In addition, by using volatility models for the price of carbon (along with standard macro risk factors) the returns of carbon futures can be forecasted on the basis of two variables from the market, namely the interbank rates which are the basis for determining bond prices and other interest rates. Furthermore, the research indicates that carbon prices tend to decrease to “recessionary shock” to global economic indicators. Still the research in this field, while fairly conclusive, can be done further to improve predictions and projections as well as to fine tune Carbon’s price to macroeconomic factors. Hence, we collected data on 1 month, 3 month, 6 month and 12 month rates for Euribor and Libor. We also collected data on the Industrial Production Index, EU inflation rates, and a major electric firm.

### 6.5 Single Regressions

The first step in running regressions was to determine how each of these factors works in isolation against carbon prices. The R-squared adjusted numbers indicates how accurate the regression equation is in response to the carbon prices. A complete list of values can be seen in Exhibit 7. Where a P value, indicating whether or not the relationship is statically significant, is above the cut off, 10%, this is also recorded. The most correlated variable was in fact the electric firm, Enlay Spa’s stock prices.

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6.6 Multiple Regressions

We ran multiple regressions to determine how the above mentioned factors affected the price of Carbon Credits when combined with each other. We split them into two categories—commodities and economic indicators. The point of this was to determine how each individual category can account for the change in the price of Carbon.

When doing the regression on commodities, we used crude oil prices, jet fuel prices, gasoline prices, heating oil prices, propane prices, the historic price of Enlay Spa and the Industrial Production Index. We used Enlay Spa (a leading electricity provider based in France) in the commodity regression because it was the closest we could get to the price of electric energy, which is a commodity. After running the regression we found that commodities could be used to explain 85.4% of the variability in the change in price of Carbon (Exhibit 8). Some variables however did have a P-value above .1 making the relationship statistically insignificant such as propane, jet fuel, crude oil and gasoline; as such they are factors that may not be as significant to the change in prices of Carbon.

After the results of the commodity regression, we proceeded to perform the regression on key economic indicators. We chose to include 1 month Libor and Euribor rates, 3 month Libor and Euribor rates, 6 month Libor and Euribor rates, 12 month Libor and Euribor rates, the European inflation rate and the Industrial Production Ended (IPI). We used the IPI in both regressions because it applies to both commodity production as well as places importantly as a key economic indicator. We found that 91.3% of the variability could be explained in the price of carbon with these regression variables. There were again several with abnormally high P-values (Exhibit 9) which may not be significant in affecting the price of carbon.

Lastly we combined the two sets of variables and through trial and error we came up with a model that correlates strong and could be used to extrapolate carbon prices. The full best fit equation we came up with can be seen in Exhibit 10. The variables that we ended up using were gasoline price, jet fuel price, 1 month Libor, 3 month Libor, 3 month Euribor, 12 month Euribor, Weather and the stock prices of Enlay Spa. Using these we ended up with an R-squared value of 94.2% which means that our model can explain 94.2% of the variability in the price of Carbon (Exhibit 11). Indeed, this was consistent with expectations as per our research which pinpointed these variables as appropriate indicators for the prices of carbon.
7. Conclusion

In conclusion, the Carbon Emission market has shown varying levels success in its operations to date. Given a significant lack of support from the United States, the EU has faced a steep learning curve and continues to face problems with regard to pricing; in order to counteract the effect of greenhouse gasses on temperature change, a global collaborate effort will be key (Exhibit 12). While the surplus of permits, suggests that the reductions have been successful, this could also be as a result of a weakened economy. Overall, the major stumbling block to resolving the pricing of carbon as a commodity necessitates a tightening of the cap, but the threat to peripheral countries in Europe is substantial as they are heavily pollutant. Optimistically, the EU commission will have learned a number of lessons that will be used for policy making in the future to preserve the planet and reduce factors of Global Warming through effective balance of carbon.
Exhibit 1: Atmospheric CO2 Levels

Exhibit 2: One Ton of Carbon Units
Exhibit 3: Kyoto Protocol Participation Map

- Green (darkgreen, and lightgreen): indicates countries that have ratified the treaty
- Dark green: Annex I & II countries with targets
- Light green: Annex I & II countries without targets
- Grey: Countries which took no position or have an unknown position
- Brown: Countries with no intention to ratify the treaty
- Red: Countries which have withdrawn from the Protocol.


Exhibit 4: Carbon Permit Surplus

<table>
<thead>
<tr>
<th>(million tonnes of CO₂)</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>Total surplus over phase II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average annual allocation</td>
<td>2,136</td>
<td>2,136</td>
<td>2,136</td>
<td>2,136</td>
<td>2,136</td>
<td></td>
</tr>
<tr>
<td>Verified emissions</td>
<td>2,120</td>
<td>1,873</td>
<td>1,932</td>
<td>Estimate</td>
<td>Estimate</td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td>16</td>
<td>262</td>
<td>203</td>
<td>200</td>
<td>200</td>
<td>881</td>
</tr>
</tbody>
</table>

Exhibit 5: Expected CERs from CDMs

Expected annual average CERs from registered projects by host party. Total: 701,487,878

- China (35.15%)
- India (10.33%)
- Mexico (5.66%)
- Republic of Korea (2.66%)
- Brazil (3.86%)
- Others (17.03%)
- Malaysia (1.01%)
- Viet Nam (1.52%)
- Indonesia (1.61%)

Exhibit 6: Wind Turbines

Exhibit 7: Single Regression Results

<table>
<thead>
<tr>
<th>Variable</th>
<th>R squared (Adj)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU Inflation</td>
<td>11.10%</td>
<td></td>
</tr>
<tr>
<td>Crude Oil</td>
<td>19.20%</td>
<td></td>
</tr>
<tr>
<td>Industrial Production Index</td>
<td>0.00%</td>
<td>0.646</td>
</tr>
<tr>
<td>Gasoline</td>
<td>22.80%</td>
<td></td>
</tr>
<tr>
<td>Heating Oil</td>
<td>24.20%</td>
<td></td>
</tr>
<tr>
<td>Propane</td>
<td>6.10%</td>
<td></td>
</tr>
<tr>
<td>Jet Fuel</td>
<td>21.80%</td>
<td></td>
</tr>
<tr>
<td>Enlay Spa</td>
<td>56.30%</td>
<td></td>
</tr>
<tr>
<td>1 month Libor</td>
<td>0.00%</td>
<td>0.377</td>
</tr>
<tr>
<td>3 month Libor</td>
<td>35.10%</td>
<td></td>
</tr>
<tr>
<td>6 month Libor</td>
<td>47.20%</td>
<td></td>
</tr>
<tr>
<td>12 month Libor</td>
<td>19.40%</td>
<td></td>
</tr>
<tr>
<td>1 month Euribor</td>
<td>0.40%</td>
<td>0.288</td>
</tr>
<tr>
<td>3 month Euribor</td>
<td>5.90%</td>
<td></td>
</tr>
<tr>
<td>6 month Euribor</td>
<td>5.80%</td>
<td></td>
</tr>
<tr>
<td>12 month Euribor</td>
<td>7.00%</td>
<td></td>
</tr>
<tr>
<td>Weather</td>
<td>0.00%</td>
<td>0.836</td>
</tr>
</tbody>
</table>
Exhibit 8: Multiple Regression: Commodities

The regression equation is
Carbon Prices = - 52.5 + 0.140 Crude Oil Prices + 0.687 Industrial Production Index + 2.51 Gasoline + 7.44 Jet Fuel - 20.3 Heating Oil + 0.17 Propane + 2.47 Enlyay Spa

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Coef</th>
<th>SE Coef</th>
<th>T</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-52.51</td>
<td>13.99</td>
<td>-3.75</td>
<td>0.001</td>
</tr>
<tr>
<td>Crude Oil Prices</td>
<td>0.1403</td>
<td>0.1116</td>
<td>1.26</td>
<td>0.219</td>
</tr>
<tr>
<td>Industrial Production Index</td>
<td>0.6867</td>
<td>0.1507</td>
<td>4.56</td>
<td>0.000</td>
</tr>
<tr>
<td>Gasoline</td>
<td>2.509</td>
<td>2.938</td>
<td>0.85</td>
<td>0.400</td>
</tr>
<tr>
<td>Jet Fuel</td>
<td>7.438</td>
<td>9.542</td>
<td>0.78</td>
<td>0.442</td>
</tr>
<tr>
<td>Heating Oil</td>
<td>-20.333</td>
<td>9.564</td>
<td>-2.13</td>
<td>0.042</td>
</tr>
<tr>
<td>Propane</td>
<td>0.172</td>
<td>1.984</td>
<td>0.09</td>
<td>0.932</td>
</tr>
<tr>
<td>Enlyay Spa</td>
<td>2.4706</td>
<td>0.4278</td>
<td>5.78</td>
<td>0.000</td>
</tr>
</tbody>
</table>

S = 1.31066 \quad R-Sq = 88.3\%  \quad R-Sq(adj) = 85.4\%

Analysis of Variance
Source          DF       SS      MS      F      P
Regression      7  362.410  51.773  30.14  0.000
Residual Error  28   48.100   1.718
Total           35  410.509

Exhibit 9: Multiple Regressions: Economy Indicators

Regression Analysis: Carbon Price versus EU Inflation, 12 Month Eur, ...

The regression equation is
Carbon Prices = - 53.1 - 16.4 EU Inflation + 19.8 12 Month Euribor - 16.8 6 Month Euribor - 0.66 3 Month Euribor - 2.39 1 Month Euribor + 11.7 12 Month Libor - 6.4 6 Month Libor - 41.4 3 Month Libor + 72.5 1 Month Libor + 0.483 Industrial Production Index

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Coef</th>
<th>SE Coef</th>
<th>T</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-53.05</td>
<td>23.39</td>
<td>-2.27</td>
<td>0.032</td>
</tr>
<tr>
<td>EU Inflation</td>
<td>-16.43</td>
<td>81.23</td>
<td>-0.20</td>
<td>0.841</td>
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<tr>
<td>12 Month Euribor</td>
<td>19.825</td>
<td>6.552</td>
<td>3.03</td>
<td>0.006</td>
</tr>
<tr>
<td>6 Month Euribor</td>
<td>-16.767</td>
<td>9.148</td>
<td>-1.83</td>
<td>0.079</td>
</tr>
<tr>
<td>3 Month Euribor</td>
<td>-0.662</td>
<td>5.380</td>
<td>-0.12</td>
<td>0.903</td>
</tr>
<tr>
<td>1 Month Euribor</td>
<td>-2.390</td>
<td>2.643</td>
<td>-0.90</td>
<td>0.375</td>
</tr>
<tr>
<td>12 Month Libor</td>
<td>11.694</td>
<td>6.486</td>
<td>1.80</td>
<td>0.083</td>
</tr>
<tr>
<td>6 Month Libor</td>
<td>-6.44</td>
<td>11.84</td>
<td>-0.54</td>
<td>0.592</td>
</tr>
<tr>
<td>3 Month Libor</td>
<td>-41.37</td>
<td>13.25</td>
<td>-3.12</td>
<td>0.004</td>
</tr>
<tr>
<td>1 Month Libor</td>
<td>72.50</td>
<td>13.60</td>
<td>5.33</td>
<td>0.000</td>
</tr>
<tr>
<td>Industrial Production Index</td>
<td>0.4827</td>
<td>0.2453</td>
<td>1.97</td>
<td>0.060</td>
</tr>
</tbody>
</table>

S = 1.01145 \quad R-Sq = 93.8\%  \quad R-Sq(adj) = 91.3\%

Analysis of Variance
Source          DF       SS      MS      F      P
Regression      10  384.934  38.493  37.63  0.000
Residual Error  25   25.576   1.023
Total           35  410.509
Exhibit 10: Multiple Regression Best Fit

**Regression Analysis: Carbon Prices versus Gasoline, Jet Fuel, ...**

The regression equation is:

\[
\text{Carbon Prices} = -22.0 + 3.51 \text{ Gasoline} - 3.95 \text{ Jet Fuel} + 76.3 \text{ 1 Month Libor} \\
- 29.0 \text{ 3 Month Libor} - 11.8 \text{ 3 Month Euribor} \\
+ 12.3 \text{ 12 Month Euribor} - 0.0538 \text{ Weather} + 1.14 \text{ Enlyay Spa} \\
+ 0.179 \text{ Industrial Production Index}
\]

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Coef</th>
<th>SE Coef</th>
<th>T</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-21.98</td>
<td>11.58</td>
<td>-1.90</td>
<td>0.069</td>
</tr>
<tr>
<td>Gasoline</td>
<td>3.508</td>
<td>2.082</td>
<td>1.68</td>
<td>0.104</td>
</tr>
<tr>
<td>Jet Fuel</td>
<td>-3.953</td>
<td>2.351</td>
<td>-1.68</td>
<td>0.105</td>
</tr>
<tr>
<td>1 Month Libor</td>
<td>76.26</td>
<td>12.98</td>
<td>5.88</td>
<td>0.000</td>
</tr>
<tr>
<td>3 Month Libor</td>
<td>-29.009</td>
<td>5.160</td>
<td>-5.62</td>
<td>0.000</td>
</tr>
<tr>
<td>3 Month Euribor</td>
<td>-11.833</td>
<td>3.430</td>
<td>-3.45</td>
<td>0.002</td>
</tr>
<tr>
<td>12 Month Euribor</td>
<td>12.334</td>
<td>3.542</td>
<td>3.48</td>
<td>0.002</td>
</tr>
<tr>
<td>Weather</td>
<td>-0.05378</td>
<td>0.01799</td>
<td>-2.99</td>
<td>0.006</td>
</tr>
<tr>
<td>Enlyay Spa</td>
<td>1.1386</td>
<td>0.4513</td>
<td>2.52</td>
<td>0.018</td>
</tr>
<tr>
<td>Industrial Production Index</td>
<td>0.1794</td>
<td>0.1407</td>
<td>1.28</td>
<td>0.213</td>
</tr>
</tbody>
</table>

\[S = 0.827678 \quad R^2 = 95.7\% \quad R^2(\text{adj}) = 94.2\%\]

**Analysis of Variance**

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>P</th>
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<tbody>
<tr>
<td>Regression</td>
<td>9</td>
<td>392.698</td>
<td>43.633</td>
<td>63.69</td>
<td>0.000</td>
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<tr>
<td>Residual Error</td>
<td>26</td>
<td>17.811</td>
<td>0.685</td>
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<td></td>
</tr>
<tr>
<td>Total</td>
<td>35</td>
<td>410.509</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Exhibit 11: Carbon Prices and Regression Equation Comparison

Scatterplot of Carbon Prices vs Date

Scatterplot of Regression 2 vs Date

12/2/2012 10:26:15 PM

12/2/2012 10:26:04 PM
Exhibit 12: Need for Collaboration

Suppose I pay one of you who don’t share my problem with overabundant gas emissions... I buy your “right” to emit gas. Problem solved?

STUCK ON AN ELEVATOR WITH THE U.S. AT THE UN GLOBAL WARMING CONFERENCE
References


"I pledge my honor that I have neither received nor provided any unauthorized assistance during the completion of this work."

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