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Assessing CO2 Emissions Reduction: Progress toward the Kyoto Protocol Goals in the European Union

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ABSTRACT

The second phase of the Kyoto Protocol began in 2008. European nations had committed to reduce greenhouse gases (GHG) by an average of 8 percent from the base year 1990 by the end of 2012. A little less than half of the actual reduction in GHG emissions was achieved by implementing a market-based cap and trade mechanism. In this paper we evaluate the effectiveness of cap and trade as the preferred method for reducing carbon emissions. To do this, an examination is made of emissions for 14 European countries that are the largest GHG emitters in Europe. We conclude that using cap and trade in combination with other measures that reduce GHG emissions led to the EU achieving its Kyoto Protocol goals.

Keywords: Cap and Trade, Climate Change, GHG Emissions, Kyoto Protocol.
JEL Codes: Q5, Q52, Q53, Q54.
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1.0 INTRODUCTION

A sense of global urgency emerges with the commencing of the Paris conference on climate change. Alarming statistics, voiced by the scientific community, point out that the earth's temperature has increased by 1.7 degrees Fahrenheit (Gillis 2015), and that in all likelihood the increase in global temperature since 1950 is due for the most part to human activity (Gillis 2015). Furthermore, scientists believe that if carbon emission continues at the current rate, it will have catastrophic effects on the planet. Scientists' dire predictions range from severe and devastating weather events to questioning the planet's ability to support the population.

The urgency of the Paris conference follows a realization that all other treaties failed to achieve a global agreement. In fact, the only international treaty to date that was signed and implemented is the Kyoto

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Protocol. Analyzing the effectiveness of the policies implemented under the Kyoto Protocol provides insight to future global policies designed to reduce carbon emissions.

In this paper we examine how successful the Kyoto Protocol was in reducing carbon emissions and we analyze the effectiveness of the cap and trade mechanism in bringing about a reduction in carbon emissions.

The paper is structured as follows: We begin with a brief background of events that led to the Kyoto Protocol and a description of the essence of that treaty. We then summarize and explain the economic theory underlining cap and trade and the reasons for its being an attractive instrument in the effort to reduce carbon emissions. Next, a literature review is provided which leads to a description of the research questions and study methodology. The collected data are analyzed and the research outcomes discussed in detail. Finally, conclusions and policy implications are provided.

2.0 BACKGROUND AND LITERATURE REVIEW

Incontrovertible scientific evidence shows that emissions of carbon dioxide (CO_2) and other greenhouse gases (GHG) are the major contributors to climate change. In an attempt to address this threat, a global treaty termed the "United Nations Framework Convention on Climate Change" was enunciated. The treaty, signed in Rio de Janeiro during 1992, alerted the global community to the need for action to prevent the rise of CO_2 concentrations in the atmosphere, but fell short of specifying exactly how to accomplish that abatement (Kolbert 2015). Following the Rio Earth Summit, subsequent annual meetings—each termed a "Conference of the Parties" (COP)—were held to further discuss and strengthen the Rio treaty. The third meeting (COP 3) in 1997 resulted in the Kyoto Protocol (KP). Under the KP, most industrialized nations committed to cut CO_2 emissions. The EU governments agreed to cut GHG emissions to 92 percent of their 1990 level by the end of 2012.

Meeting the KP goals required each country to implement various methodologies to reduce emissions. Cap and trade was a central piece of the legislation passed by the EU to limit carbon emissions (EEA Report No. 10/2013). Nearly half of the reduction in carbon emissions was achieved using this policy (EEA Report No. 10/2013). Cap and trade is, essentially, a market-driven instrumentality rooted in economic theory (see, for example, Dales 1968 and Montgomery 1972) whereby government and pollution-generating firms create a market for "pollution rights." A detailed description of the mechanism can be found in Tietenberg and Lewis (2009), Tietenberg (2003), or Hahn and Hester (1989).

Firms that create noxious effluents must hold permits to emit. These rights are initially allocated or auctioned by a government through issuance of a limited number of permits. Each permit allows the polluter to emit a certain volume of effluent, with a fine imposed for excess emission. A market develops since some polluters have excess permits not needed to cover their emissions while others require more permits to accommodate their excess pollution and avoid being fined. Buying and selling permits creates this market for pollution rights. Economic theory predicts that this system will provide polluters an incentive to cut pollution in a cost effective way to achieve the aggregate reduction goal. Individual actors with expectations of excess effluent production will pay as much as their projected fines to either change production outcomes and avoid the penalty or acquire additional permits to cover their excesses.

To implement what has come to be known as the European Union Emissions Trading System (EU-ETS), each EU country received a pre-determined number of pollution permits/allowances (EEA Report No. 10/2013). These allowances were distributed annually to various plants in each industry at no cost to the recipients. Companies that emitted CO_2 surrendered the appropriate number of allowances to the government based on their verified carbon emissions. Firms that emitted less carbon than their allocated allowances had the option to save ("bank") unneeded permits or to sell unused allowances to others who emitted more than their designated allowances. Policy makers envisioned, based on the underlying economic theory, that as governments gradually reduced the number of freely allocated allowances over time to meet the KP objectives, the forces of supply and demand would drive permit prices higher. With

this scenario, rational economic operators would alter production for the longer term so that fines would not be levied and costly additional permits would not have to be acquired in the marketplace. In other words, an orderly market-based approach under the cap and trade system was expected to use the economic incentive/disincentive to drive fundamental production changes in the direction of lower effluent outputs. Policy makers envisioned, in the EU at least, that fiscal constraints imposed by a free market system would lead to better outcomes than had earlier been obtained by using government fiat or command-and-control techniques to control pollution emissions.

Numerous studies have measured the effectiveness of cap and trade in cutting carbon emissions. Tietenberg (2013), for example, reports that implementing EU-ETS contributed to an 8 percent reduction in carbon emissions between the years 2005 and 2010, but cautioned (p. 138) that the reduction may have been due partly to the global recession. In another preliminary investigation of the effectiveness of the EU-ETS, Ellerman and Buchner (2008), examining data from 2005 and 2006, conclude that the reduction in carbon emissions is due to both abatement efforts and over-allocation of allowances. In a related paper, Murray, Maniloff, and Murray (2013) investigated the effectiveness of cap and trade in certain regions of the United States. They conclude that several factors, such as the increase in supply of natural gas and the global recession, together with market incentives (i.e., a cap and trade mechanism) account for the observed decline in carbon emissions. Finally, Bel and Stephan (2015) attempt to identify the causes for the reduction in carbon emissions during phase I and II of the KP. They conclude that the reduction is due to both cap and trade and the global recession—without specifying the weight that these two driving sources contributed to the CO_2 reduction.

In this paper, we analyze and evaluate whether the KP goals were achieved. Our focus is on the years 2008 to 2012, the complete so-called "second stage," or Stage II, of KP when European countries agreed to cut emissions by 8 percent relative to the 1990 level. The EU-ETS cap and trade mechanism was implemented as the favored method to achieve this reduction. Specifically, we ask the following questions:

1. Which EU countries were successful in achieving the KP target of reducing emissions by 8 percent by the end of 2012 from the base year of 1990?
2. How well did each country do after accounting for in changes in domestic output and population size?
3. How successful was the energy sector, the major polluting segment of the macro-economy, in reducing carbon emissions?
4. Did cap and trade prove to be an effective method in reducing carbon emissions?

3.0 METHODOLOGY

Using descriptive statistics, both numeric and graphical, we analyze carbon emissions (including GHG per capita and GHG outputs related to GDP per capita amounts) from those European countries that are the major emitters of carbon waste. Thirteen of these nations—Belgium, the Czech Republic, Denmark, Finland, France, Germany, Greece, Italy, the Netherlands, Poland, Spain, Sweden, and the United Kingdom—are EU members and one, Norway, is not. We use data compiled by the European Environmental Agency (EEA) to report on progress toward meeting the Kyoto target of having the volume of CO_2 emitted during 2012 be at 92 percent of the volume of this effluent measured in the base year 1990. Data all are obtained from the EEA greenhouse gas data viewer and the EEA EU-ETS data viewer as made available during 2013.

4.0 DATA ANALYSIS

The data analysis includes the change in emissions comparing the base year (1990) to the end of the Kyoto Protocol period (2012), with a more detailed examination of trends in emissions over the years 2008 to 2012 for each country. In addition, we take a closer look at the energy industry as it is the primary source of carbon emissions throughout Europe.

These data are viewed from two perspectives:

1. Trends in overall GHG emissions: Did the study countries meet the KP target and reduce GHG emissions by 8 percent from their 1990 level? Were any significant patterns observed during the 2008 to 2012 period with respect to CO_2 emissions?
2. Was implementation of the cap and trade mechanism effective?
   a. Did the study countries emit within their allocated allowances? Were there any significant patterns over time in the number of allowances used and verified emissions?
   b. With respect to the energy industry, did the countries emit within their allocated allowances? Were there any significant patterns over time in the number of allowances used and verified emissions?
   c. Given that about 50 percent of total reduction in carbon emissions is achieved by using the ETS mechanism, how does that result compare to the reduction in emissions using other techniques?

A. TRENDS IN OVERALL EMISSIONS OF GHG

The EU defines a composite basket of GHG to include CO_2 as well as methane, nitrous oxide, and several fluorinated gases. Carbon dioxide, though, is the principal component in the GHG emissions volumetric output, comprising over 80 percent of total GHG according to the Annual European Union greenhouse gas inventories from 1990 to 2011 and the 2013 inventory report.

As agreed to by the EU, the KP calls for an 8 percent reduction in emissions of GHG by the end of 2012 relative to the 1990 base year. Comparing the emissions level in 2012 to that of 1990, we find that all but three countries in this study (Greece, Spain, and Norway) met the Kyoto targets. In fact, comparing these three countries' pollution levels between 1990 and 2012, the volume of their CO_2 emissions actually increased by about 10 percent, 22 percent and 5 percent respectively. Thus, the first conclusion is that the KP target of an 8 percent reduction in carbon emissions was met by most countries.

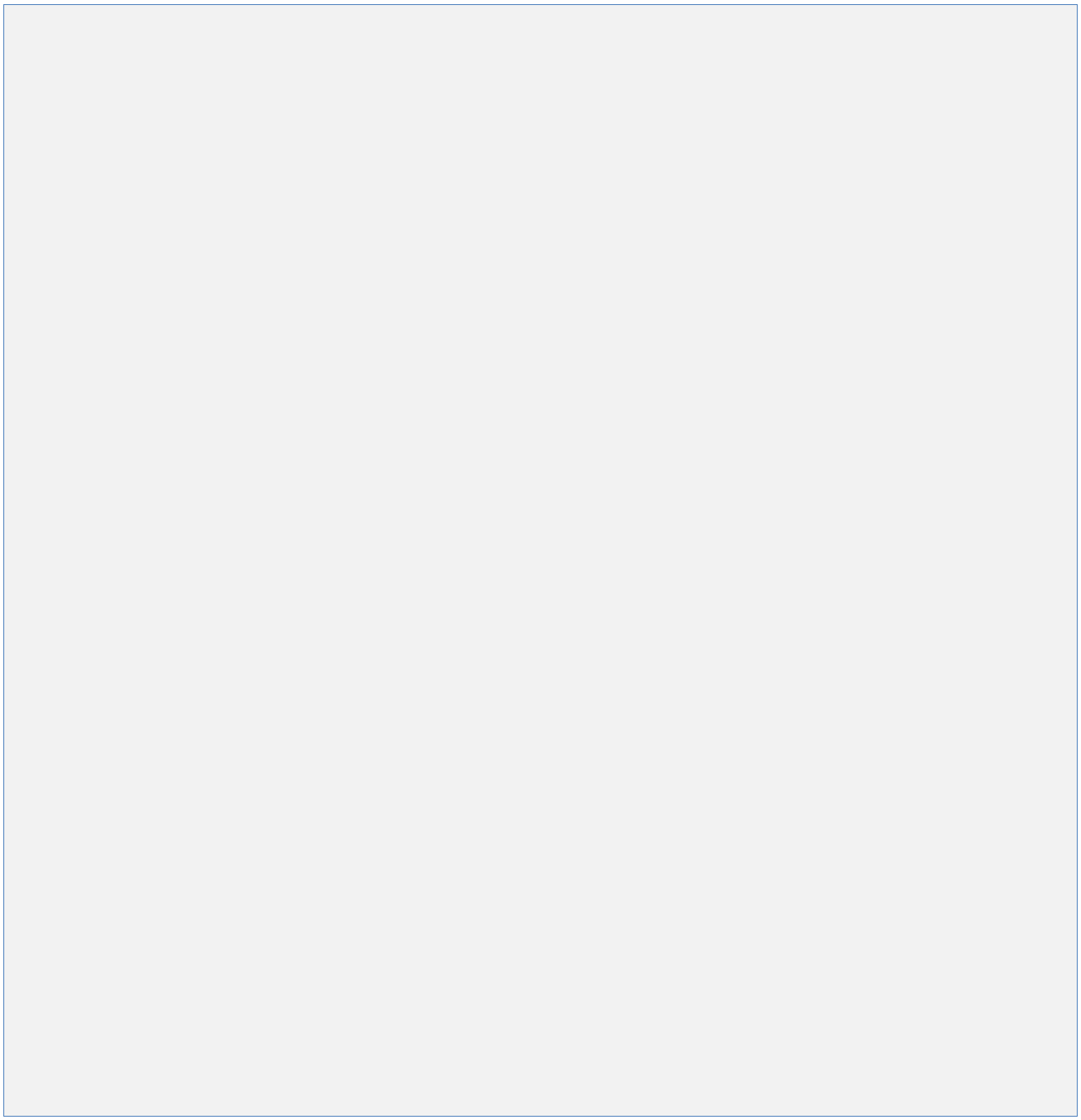
Examining these data in a more focused way, we find that in a comparison of emission levels in 2007—just before the KP's second stage began—and pollutant volumes at the end of 2012—when the commitment period for the 8 percent reduction concluded—all 14 countries studied had reduced their annual emissions. The extent of the reduction varies from about 5 percent for Germany to 21 percent in Finland. The significance of this finding is that all countries in the study achieved their agreement to carbon reduction during Stage II of KP implementation in Europe.

In addition to the overall change in GHG emissions just reported, we compared the change in emissions as calculated by GHG on a per capita GDP basis and GHG per capita. These data are shown in Table 1. We find very strong evidence of emissions reduction when using these measurements. In comparing 2012 levels to those of 1990, the base year, we find that both GHG per GDP and GHG per capita were significantly reduced. Furthermore, when comparing 2008 (the first year of Stage II) to that of 2012, we again find a significant reduction. The only exception is GHG per capita for Spain where there was a slight increase from 1990 to 2012.

Analyzing the change in emission levels year by year for the duration of the second stage of KP reveals that although there was a drop in emissions between the base year and the end of the KP commitment period, that reduction has not been consistent in each annual period. In fact, there is considerable variation in emissions.

Table 01: Greenhouse gas emissions/GDP and per capita by country

	GHG per GDP				
Country	**1990**	**2008**	**2012**	**%change:1990-2012**	**%change:2008-2012**
Belgium	635.9	464	369.5	-41.89	-20.36
Czech Republic	2412.2	1645	1062.4	-55.95	-35.4
Denmark	455.8	332	246.7	-45.87	-25.69



Not unsurprisingly, this annual variability is positively correlated with global economic activity. For example, all countries show a drop in overall GHG emissions from 2008 to 2009. This reduction might be explained by the global recession. Similarly, most countries show an increase in emissions from 2009 to 2010. Again, we might ascribe this change to the beginning of the economic recovery period. As production increased, so did the level of GHG emissions. The fact that Stage II of KP coincided with the great recession, the recovery, and the prolonged economic challenges in the EU, may hinder our ability to assert cause and effect. The reduction in carbon emissions might be related to underlying economic activity more than to a deliberate policy measure. Very cautiously, then, we conclude that reduction in GHG emissions toward the Kyoto goal was successful and that most countries met their target. However, as we look forward, we believe that from a policy perspective governments should aim at achieving a consistent, continuous drop in GHG emissions that is independent of economic fluctuations.

B. EFFECTIVENESS OF IMPLEMENTATION OF CAP AND TRADE

1. EMITTING WITHIN ALLOCATED ALLOWANCE

EU members implemented cap and trade to reduce carbon emissions. Under the EU-ETS, each participating government issued free carbon allowances each year to firms within the following nine industrial sectors: combustion installations; mineral oil refineries; coke ovens; metal ore roasting or sintering; pig iron or steel production; cement, clinker, or lime facilities; glass, including glass fiber; ceramic products created by firing; pulp, paper, and board. An additional tenth category included all other production facilities that voluntarily had opted to be part of the trading system. The first industry designation, combustion installations, is by far the largest industry group and the major source of carbon emissions—and, therefore, we will pay particular attention to this group of firms in the analysis given below.

The share of EU-ETS emissions out of total emissions varied from one country to another. In 2012, as an example, France's ETS emissions accounted for about 21 percent of the country's total GHG emissions, whereas Greece's ETS emissions were 53 percent of its total emissions. The UK's ETS emissions comprise 41 percent of total emissions, and Spain's were 39 percent. Despite this wide variation in percentages, all countries used ETS extensively; clearly the ETS was an important mechanism in attempting to reduce carbon emissions.

Was the ETS a successful mechanism in achieving carbon emissions reduction goals? To answer this question we compared two sets of data that are shown in Table 2. Both data sets matched verified emissions to the number of allowances allocated to the particular industry. The difference between the data sets lies in the definition and calculation of allowances. In one data set the allowances are called "free allowances" and are based on the desired or planned level of emissions reduction, whereas in the other data set the allowances are called "all allowances" since they aggregate the free allowances with an adjustment made for buying, selling, or issuing more allowances. The source for all these data is www.eea.europa.eu/data-and-maps/data/data-viewers/emissions-trading-viewer

We look first at the data set comparing verified emissions to all allowances in the right-most panel of the table below. Using this data set, it can be noted that most countries' verified emissions fell within the allocated allowances for the five years involved. However, there are some notable exceptions. Germany, for example, had a verified emissions level that was greater than its allowances in 2008, 2010, and 2011. Denmark's and Finland's verified emissions in 2010 were greater than their allowances. Norway's verified emission level was consistently higher than permits allotted in the country; however, the extent of the deviation there declined from 2010 to 2012.

Table 02: A comparison of carbon emissions to allowances 2008-2012

Country	Verified Emissions *vs* Free Allowances					Verified Emissions *vs* All Allowances				
	2008	2009	2010	2011	2012	2008	2009	2010	2011	2012
Belgium	+	-	-	-	-	+	-	-	-	-
Czech Republic	-	-	-	-	-	-	-	-	-	-
Denmark	+	+	+	-	-	+	+	+	-	-
Finland	-	-	+	-	-	-	-	+	-	-
France	-	-	-	-	-	-	-	-	-	-
Germany	+	+	+	+	+	+	-	+	+	-
Greece	+	+	-	-	-	+	+	-	-	-
Italy	+	-	-	-	-	+	-	-	-	-
Netherlands	+	-	-	-	-	+	-	-	-	-
Norway	+	+	+	+	+	+	-	+	+	+
Poland	+	-	-	-	-	+	-	-	-	-
Spain	+	-	-	-	-	+	-	-	-	-

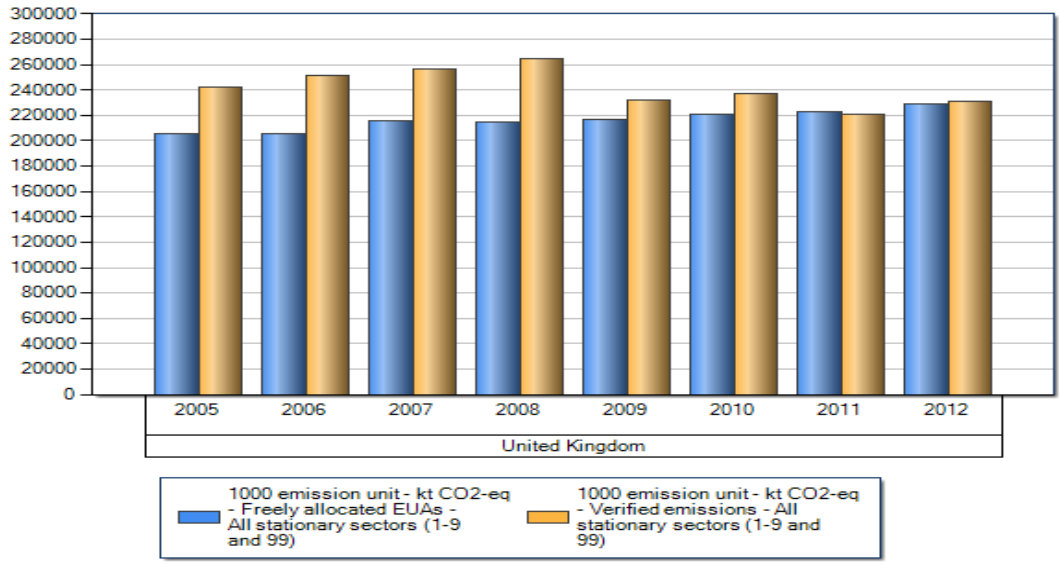
Sweden	-	-	-	-	-		-	-	-	-	-
United Kingdom	+	+	+	-	+		+	-	-	-	-

Table note: A negative sign indicates verified emissions are within the allocated allowances, whereas a positive sign indicates an emissions level that is greater than the allocated allowances.

It also is interesting to note that most countries' verified emissions in 2008 exceeded their allowances. A possible explanation is that 2008 was the first "official" year of using EU-ETS and countries had not adjusted yet to the new system—even though 2005 through 2007 was designated as a trial and error period when countries (other than Norway) tested the EU-ETS implementation. We conclude that using this measure supports the idea that cap and trade was instrumental in providing incentives to reduce carbon emissions. That is, most countries emitted carbon in accordance with their allocated allowances, and reduced their emission levels to match the number of allowances available.

The second data set in the table (left-hand panel) compares verified emissions to the free allocation of allowances. Using this data set, we find similar patterns to the ones reported for the first data set, again with certain identifiable exceptions. Germany, Norway, and the UK show performance using the "free allowances" measure that was worse than when using the measure "all allowances." For example, the UK's verified emissions exceeded the "free allowances" for all years except 2011. This is depicted in Graph 1 shown below.

Graph 01: UK's Emissions and Allowances 2005-2012



Source: www.eea.europa.eu/data-and-maps/data/data-viewers/emissions-trading-viewer

Even though most countries exhibit similar patterns under both sets of measurements, comparing verified emission data to the broader class of allowances (the "all allowances" comparisons) depicts a greater degree of compliance—or success—in meeting the KP goals. It is important to distinguish between these two measures. The "free allowances" assessment reflects the basic intent of KP and the participating countries' attempts to engineer an emissions reduction through a specific limitation in the number of allowances allotted. The actual number of allowances under "free allowances" was determined by the KP goal targets and by estimating the feasibility of the current technology. The broader data set, "all allowances," uses the measure of free permits plus/minus traded allowances. This latter measure captures the essence of a market for carbon—the underlying cap and trade element in the system. As such, the second evaluation shows how the market for carbon emissions evolved since it includes the outcomes of the actual trading of allowances. In the context of the research reported here, using this broader data set seems to be the more appropriate way to judge compliance with the Kyoto Protocol.

Unlike the market for normal goods, though, the market for pollution rights comes with a special provision—a fixed supply of allowances—that significantly alters the arena in which transactions will occur. The rationale for this particular market reflects the ultimate goal of reducing carbon emissions so that the cap is effective in limiting the yearly volume of effluents. Under cap and trade, as the number of allowances becomes smaller (a decrease in annual supply over time), the price of the allowances increases. This market mechanism is expected to provide the financial incentive to reduce emissions—either through changed input types or implementation of enhanced (i.e., "cleaner") production technologies.

In practice, however, we know that the spirit of cap and trade was not followed completely during the period under study. The "cap" part of the mechanism was only loosely applied: instead of continuously reducing the number of allowances issued, there were many cases in which the number of allowances continually increased. Yet, an essential component of the EU-ETS is the limit on allowances. The cap artificially creates scarcity, so that the longer-term target is met, and puts upward pressure on price. Higher prices for permits, and larger fines for not meeting the quotas, provide the incentive to cut emissions. However, throughout the duration of KP, the market price of allowances actually declined.

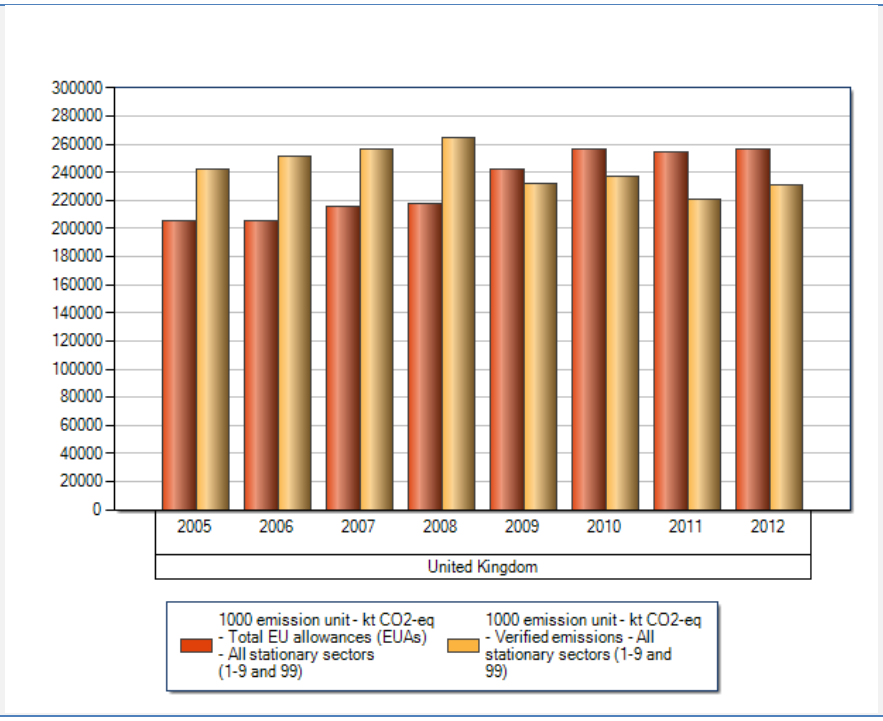
Complicating matters further was firms' behavior on the demand side of the market equation. Demand for allowances fluctuated widely with the economic upheaval during the 2008 to 2010 period. A considerable drop in demand occurred between 2008 and 2009, when verified emissions fell due to the global recession (Aldy and Stavins 2012); put simply, demand for permits collapsed because productive output—and pollution creation—tumbled. As expected, the price of allowances declined since these goods were in strictly fixed supply in the short term (that is, each year). As the global economy recovered in 2010, the level of verified emissions increased along with production. Interestingly, though, the price of the allowances did not rise. In fact, during Stage II of KP, the price of an allowance (specifically, the right to emit one ton of carbon-equivalent effluent) dropped from about $20 to $10 (Sopher and Mansell 2013).

We believe that one reason the price did not rise has to do with the increase in allocations distributed. For example, the UK was granted an increased number of allowances during the KP commitment period from 2005 to 2012. Graph 2, below, shows the aggregated comparison each year between allowances granted in the UK and yearly verified emissions.

To summarize, both data sets indicate that most countries in this study met the EU-ETS goals with respect to the targets set after Kyoto ratification. That is, most countries, in most years, demonstrate a level of verified emissions that is within their allocated allowances. As expected, we see stronger compliance under the broader data set. For example, when comparing compliance for the UK using the "free allowances" *versus* "all allowances," it is easily noted that the latter shows the UK is now in compliance with KP targets.

It is obvious that extreme caution is required when interpreting these data to indicate success of the cap and trade market mechanism. If we ask the uncomplicated question: "Was the EU-ETS a successful scheme for reducing emissions?" the answer indicated is "yes, with reservations." "Yes" because the verified emissions levels, for the most part, fell within the allocated allowances. However, EU-ETS would have been more effective if policy makers had exhibited a stronger resolve to implement the cap and trade system in accordance with the spirit for which it had been developed.

Graph 02: UK emissions compared to all allowances



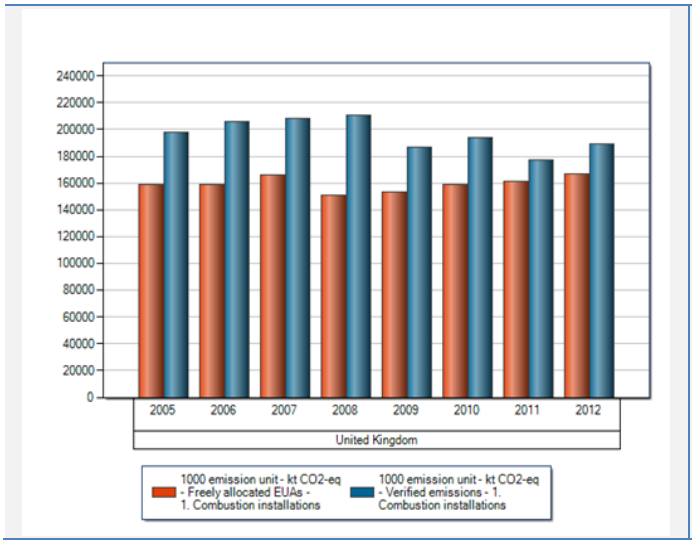
Source: //www.eea.europa.eu/data-and-maps/data/data-viewers/emissions-trading-viewer

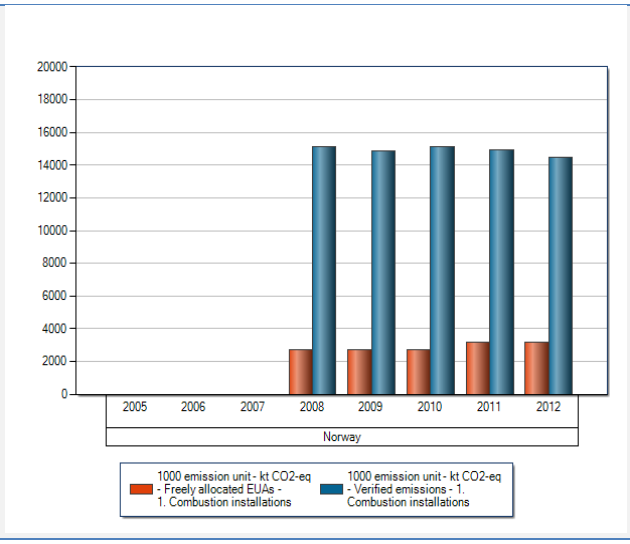
2. CAP AND TRADE IN THE ENERGY SECTOR

Under the EU-ETS program, participating countries designated ten industrial sectors that would take part in carbon trading. The first sector, "combustion installations," is the largest emitter of carbon; this is the energy sector and includes all power generating facilities. Focusing on this group of plants provides a key indicator of how successful cap and trade was in assisting countries to meet their KP goals. The data indicate that some countries were more successful in meeting the EU-ETS targets than others. We found the best performers to be the Czech Republic and France, where verified emissions fell within the allocated allowances for the duration of Stage II of the KP. The Czech Republic had its allowances held stable, but the verified emissions level declined. In comparison, for France the number of allowances increased, but verified emissions decreased from 2001 to 2012. One explanation for France's success in meeting its EU-ETS goals lies in the fact that most of the electricity generated in France comes from nuclear sources—a nearly carbon-free method of electrical power generation.

The poorest performance in meeting EU-ETS goals is demonstrated by Germany, Greece, Norway and the UK. Norway's level of verified emissions is much greater than its allocated allowances; by far the discrepancy between allowances and verified emissions is the largest for this country. This is explained by the fact that Norway's economy depends heavily on oil extracted from North Sea explorations. We should note that Norway's overall performance in meeting EU-ETS goals is better than depicted in the energy sector. Although Norway did not meet the EU-ETS goal, it narrowed the gap between the allocated allowances and verified emissions by buying more allowances and exceeding the goals in other sectors (namely, sectors classified as, 8, 9 and 99). Germany and the UK, the two largest economies in the EU, did not manage to keep their verified emissions within the allocated allowances for the duration of Stage II of KP. Graphs 3 and 4 provide some specific country comparative performance. Graph 3 shows the UK's experience; Norway's outcomes are shown in Graph 4. Data for both of these graphs are from www.eea.europa.eu/data-and-maps/data/data-viewers/emissions-trading-viewer.

Graph 03: UK's energy sector	**Graph 04:** Norway's energy sector





In addition, when examining emissions data for this sector we find that some countries (i.e., Belgium, Denmark, Finland, and the Netherlands) did not meet their EU-ETS goals for 2008-2010, but met the EU-ETS goals for 2011-2012. Although each country has a slightly different variation in number of allocations and verified emissions throughout Stage II of KP, we can identify a general pattern for the fluctuating number of allowances and verified emission levels. It appears that the number of allowances changes to reflect past levels of verified emissions; the verified emission level dropped in the years 2011-2012. Again, it is possible that the global recession and later recovery caused uncertainty in economic activity. It was very difficult to predict overall production and the resulting level of carbon emissions. Because the energy sector is a major emitter of carbon, the difficulty in meeting EU-ETS targets for that sector should be closely examined as we move forward.

3. COMPARING ETS EMISSIONS TO NON-ETS EMISSIONS

To further investigate the relationship between effluent reductions and the instrument chosen to achieve the desired reduction, we analyzed emissions data for non-EU-ETS emissions. The emissions data from non-ETS sources show mixed results. With the exception of 2009-2010 when there was an increase in non-ETS emissions (this coincides with the ETS data changes and the global economic recovery), most countries in the study reduced their emissions in 2008-2012. Although some countries did not meet their non-ETS KP targets, most did. On average, the Czech Republic, Finland, France, Germany, Greece, Norway, Poland, Sweden, and the UK met their non-ETS targets, whereas Belgium, Denmark, Italy, the Netherlands, and Spain did not. Interestingly, the countries that did not meet their non-ETS target all did meet their ETS targets. Norway met its non-ETS targets, but fell short of meeting the ETS target. In addition, Germany, France, and the UK show a slight increase in non-ETS emissions from 2011-2012. This is consistent with a small increase in EU-ETS emissions for Germany and the UK. It is possible that the increase, again, may be due to a stronger recovery from the prolonged recession and economic challenges in Europe. It is interesting to note that the pattern of emission levels for Germany and the UK is the same regardless of the method used to control emissions.

To summarize, although the non-ETS data show weaker results than the ETS data, the patterns are similar and the magnitude of the differences is quite small. Therefore, we believe that cap and trade was neither significantly better nor worse than the other mechanisms applied.

5.0 DISCUSSION OF RESULTS

Although the official commitment to KP began in 2008, the years 2005 to 2007 were designated as a "trial run" of EU-ETS. By 2008, nations participating in the EU-ETS did have some experience in the implementation of cap and trade. The number of allowances allocated in 2008 was lower than the

verified emissions recorded for 2007 for all countries other than Belgium, France, and Sweden. In accordance with the theory underlying the cap and trade mechanism, the number of allowances allocated to the participating countries in 2008 was lower than that of 2007 to force a reduction in verified emissions. However, the data show that most countries' verified 2008 emissions were greater than the allocated allowances. Furthermore, the data indicate that more often than not the number of allowances allocated from 2008 to 2012 increased. That meant that the industries involved were violating their emission guidelines and that their respective governments were accommodating them by issuing more allowances. For example, Belgium, the Czech Republic, Finland, Poland, and the UK received an increasing number of allowances from 2008 to 2012. Other examples include Denmark, whose number of allowances was held steady, but then increased in 2012, and Germany and Greece that had reduced allowances in 2009, but increases since then. Italy is the only country in our study that had a reduced number of allowances every year. Spain and Sweden showed a small fluctuation, both up and down, in the number of allowances provided.

6.0 CONCLUSION AND POLICY IMPLICATIONS

We conclude that cap and trade was not any more successful than other methods in achieving the KP emissions-reduction goals. This appears to be related mainly to governments adjusting the number of allowances to previous years' verified emissions, instead of vice versa, but also because the initial allocation was free. In order for a market of pollution rights to function effectively in providing an incentive to reduce emissions, several conditions must be met. First, the supply of allowances must be restricted and declining. Next, the price for permits must reflect market conditions. Finally, there must be monetary consequences for non-compliance that at least equal the expected market price of the permits. These conditions were violated in the following ways: the number of allowances was not held constant, let alone made to decline (with France and Spain being minor exceptions); the initial free allocation of allowances did not send the correct signal to the market because it distorted the pricing mechanism and the true (negative) value of carbon, thereby failing to provide the appropriate incentive to reduce emissions. Indeed, the price of the allowances kept declining. Lastly, although the Kyoto Protocol specified that penalties would be imposed for non-compliance, there is no clear indication that this action actually was taken in the countries studied.

How do we explain, then, the overall success in meeting the year 2012 8 percent reduction in GHG relative to 1990? It is possible that these nations were "on board" with regard to the necessity of reducing carbon emissions and were determined to reduce emissions by a variety of means including new technologies, regulations, and cap and trade. KP's targets were met, and therefore KP was a success, but it is not clear that cap and trade was necessarily the best instrument to achieve the goals. This is an important and timely conclusion.

As the twenty-first session of the Conference of the Parties (COP 21) meets in Paris, some lessons can be learned from the implementation of KP. First, a real commitment on behalf of all countries is essential in accomplishing a decrease in carbon emissions. Second, as we show in our earlier Table 1, reducing GHG emissions does not choke economic growth. Third, there is no one perfect policy instrument to achieve the desired reduction in carbon emissions. Although cap and trade is hailed by many as the most effective policy, to implement cap and trade successfully the spirit of the underlying economic theory must be followed. That is, the supply of allowances must be limited, and the price of permits must reflect their scarcity.

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