

# AN ESTIMATION OF CARBON-EMISSION PRICE OF KOREA USING THE COMPARATIVE ANALOGY: A KOREAN CASE

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15<sup>th</sup> IAEE European Conference 2017

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2017.8.22

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# INTRODUCTION

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# HISTORY OF CARBON REDUCTION EFFORTS IN KOREA

Efforts	Year	Contents
Entry of the Climatic Change Convention	1993	Entry of the international Climatic Change constitute
Introduction of GHG Reduction Performance Registration System	2005	It is set to manage corporate GHG emissions
Establishing the Basic Law for Low Carbon Green Growth	2009	It is for harmonious development of the economy and environment. Also it set voluntary reduction targets which is 30% reduction from BAU in 2020 and
Introduction of the GHG Energy Target Management System	2010	It designates companies with high GHG emissions and energy consumption and encourages them to set their reduction target and to manage it
Introduction of Forest Carbon Offset System	2012	It enable trading or promotion of carbon stocks acquired through forest-based projects



There was criticism that the existing carbon management system recognizes **only direct reduction**, so it is **too rigid**.



Therefore, in order **to complement this rigidity**, Korea introduced **ETS** which is considered to be the most effective carbon reduction system in **2015**.

# KOREA CARBON TRADING SYSTEM(KETS)

## Contents

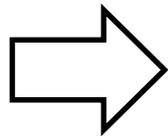
Implementing phase	The first phase : 2015-2017 The second phase : 2018-2020 The third phase : 2021-2025
Goal	To reduce GHG emissions by 37% compared to GHG emission forecast(BAU) by 2030
Participant	The companies that produce CO2 more than 125,000 tons a year or have plants that produce CO2 more than 25,000 tons a year are obliged to participate. So, a total of 525 entities including voluntary participation companies are participating in the system.
Allocation	The first phase : 100% free allocation The second phase : 97% free allocation The third phase : under 90% free allocation (But it is possible to allocate 100% initial allocation without any cost to only energy sensitive industries for keeping international competitiveness.)
Standard Price	10,000 KRW This was set to alleviate the burden of the industry. (If market price is deviated too much from standard price then government will intervene into market)
Banking/Borrowing	Banking and Borrowing are allowed
Penalty	Three times the market price or 100,000 KRW

# THE IMPORTANCE OF KOREA CARBON MARKET

## Why analysis of Korea Carbon Market is important?

- ① The first country to implement carbon trading system nationwide in Asia.
- ② The most recent carbon market
- ③ Korea is the seventh largest producer of CO<sub>2</sub>
- ④ It is not fully activated due to several problems

The main reason that the Korea carbon trading system is not fully activated is pointed out that the fair market price is not formed.(G. L. Kim, 2016, C. J. Chae & S. K. Park, 2016)



Therefore, this study aims to derive **the Market-Based Korean Carbon Price** to activate the Korea Carbon Market.

# THE OBJECTIVES OF THIS STUDY

- ✓ This study analysed EU–ETS data, which is the most stable carbon market, and tried to estimate the Market–Based Korean Carbon Price level based on EU–ETS. The major factors affecting the carbon price were selected by literature survey.
- ✓ The EU–ETS data was analyzed by regression with and without time lag. As pointed out by (Hintermann, 2010), (Aatola et al., 2013), (Mansanet–Bataller et al., 2007), the influence of each factor can occur over time.
- ✓ We conducted forecasting test for selecting the best model. In this process, we found it is more important to consider the EU–ETS Third Phase Data rather than considering time lag in analysis.
- ✓ We then estimated the Market–Based Korean Carbon Price by assigning Korean market data to selected models
- ✓ Sensitivity analysis was also performed to analyze the effect of volatility on each factor. Sensitivity analysis shows that oil and coal are important factors as same with regression analysis.

# THE RECENT STUDY TREND ON ETS

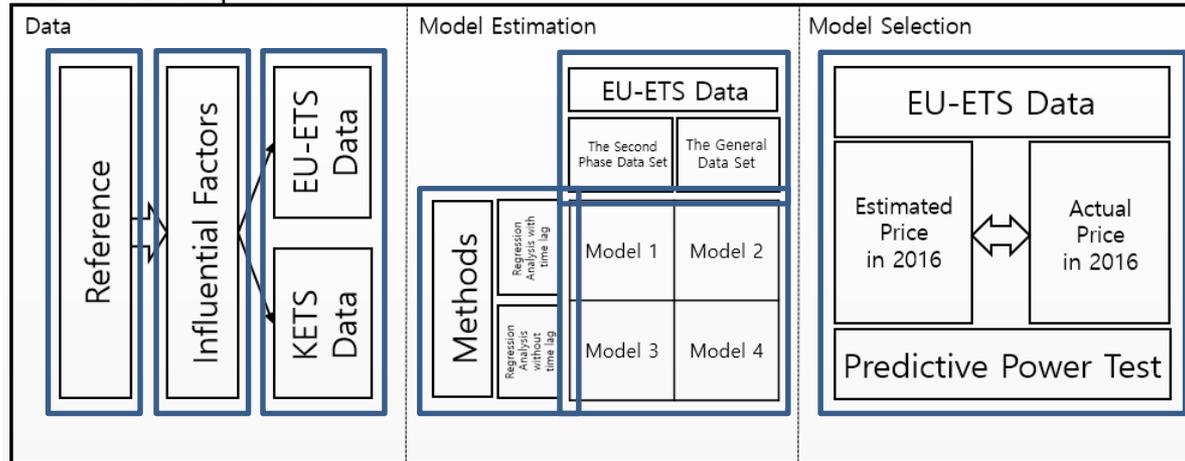
Research Field	Contents
Impact of ETS introduction on companies and industries.	<ul style="list-style-type: none"><li>• This Field focus on ETS introduction impact on net profit and product prices of the companies(Smale et al, 2006) and unit material costs, employment and revenue(Chan&amp;Zhang, 2013)</li><li>• Also, It focus on ETS introduction Impact on steel industry's(Demilly &amp; Quirion, 2008), aviation industry(Anger, 2010) , Power generation industry(Rogge &amp; Hoffmann, 2010), (Denny &amp; O'Malley, 2009) (Bonenti, Oggioni, Allevi, &amp; Marangoni, 2013)</li></ul>
The optimal strategy for the company under ETS	<ul style="list-style-type: none"><li>• This Field focus on firm's optimal strategy.</li><li>• Electricity pricing(Bonacina &amp; Gulli, 2007), optimal production planning(Gong &amp; Zhou, 2013) , optimal investment strategy(Hoffmann, 2007) and optimal CO2 trading planning(Rong &amp; Lahdelma, 2007) are mainly discussed.</li></ul>
ETS introduction effects on specific country	<ul style="list-style-type: none"><li>• The study on this field evaluate ETS introduction effects on specific country considering the country's characteristics</li><li>• It treated various countries such as China(Tang et al., 2015), New Zealand(Manley &amp; Maclaren, 2012), Malaysia(Oh &amp; Chua, 2010) and Turkey(Halicioglu, 2009).</li></ul>
A combination of ETS and other environmental policy	<ul style="list-style-type: none"><li>• This field analyzed combination effects of ETS and other climate policy such as carbon tax(De Muizon &amp; Glachant, 2004)(Lin, &amp; Lewis, 2008) and renewable electricity policy(González, 2007) (Lehmann &amp; Gawel, 2013)</li></ul>
Analysis of price determinants of carbon credits	<ul style="list-style-type: none"><li>• This field focus on investigating carbon price determinants and carbon price mechanism.</li><li>• The study on this field are divided into two part according to their EU-ETS analysis period; the case focusing EU-ETS first phase(Mansanet-Bataller et al., 2007), (Alberola et al., 2008), (Fezzi, 2007) (Hintermann, 2010)and the other case focusing EU-ETS second phase. (Keppler &amp; Mansanet-Bataller, 2010)(Aatola et al., 2013)</li></ul>

# ANALYSIS AND RESULT

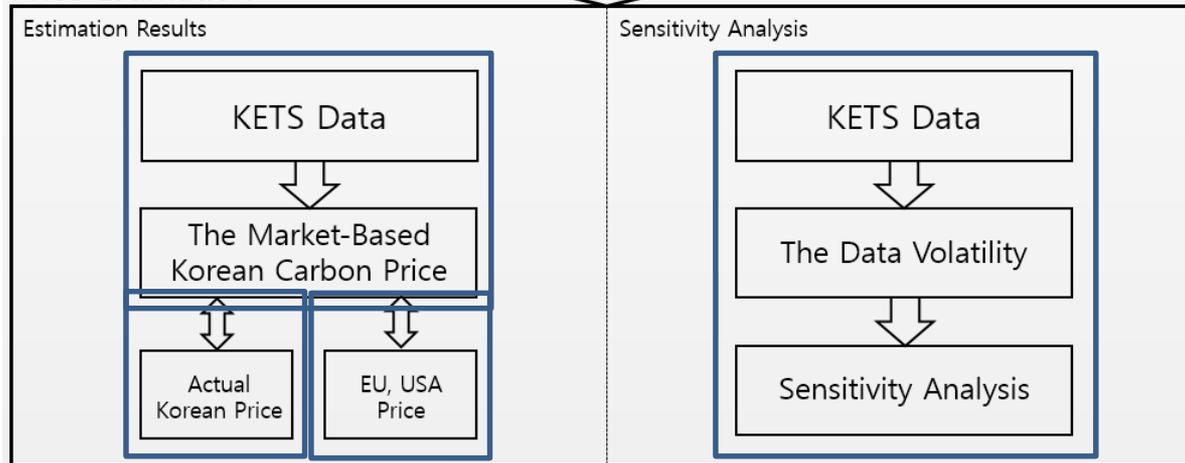
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# ANALYSIS FRAMEWORK

## Model development



## Price Estimation



# IDENTIFYING INFLUENTIAL FACTORS

Researchers	Influential Factors	Analysis Method
Maria Mansanet-Bataller et al(2007)	Oil price, Natural gas price, Temperature	CA, OLS
Hintermann (2010)	Natural Gas Prices, Coal Prices, Temperature, Precipitation	OLS
PAatola et al(2013)	Electricity price, Natural gas price, Coal price, Price of Final Goods	OLS, GARCH, IV, VAR
Keppler, Mansanet-Bataller(2010)	Temperature, Natural gas price, Electricity price, Electricity and Natural gas price difference (CDS), Economy	OLS, GCT
Sui Kim(2007)	Coal price, Oil price, Natural gas price, Coal-natural gas price difference (CGD)	GCT, IRA, VD, CA
J.H. Baek, H.S. Kim(2013)	Electricity price, Oil price, Temperature, ETS policy factors	VAR
G.D. Boo, G.H. Jeong(2011)	Oil price, Electricity price, Natural gas price, Coal price, Economy	SVECM

\* OLS= Ordinary Least Square, CA= Correlation Analysis, IV= Instrument Variable, VAR= Vector Auto-Regression, GCT= Granger Causality Test, VD= Variance Decomposition, SVECM= Structural Vector Error Correction Model,

# THE REGRESSION ANALYSIS RESULTS

## <The Results of Regression Analysis without Time Lag >

Data set	Influential Factors						Adj. R <sup>2</sup>
	Intercept	Gas	Economy	Oil	Winter	Coal	
<b>Second Phase Data Set</b>	0.08	0.07 <sup>***</sup>	0.20 <sup>***</sup>	-0.13 <sup>***</sup>	-3.23 <sup>***</sup>	0.14 <sup>***</sup>	0.914
<b>General Data Set</b>	5.56 <sup>***</sup>	0.09 <sup>***</sup>	-	-0.15 <sup>***</sup>	-2.16 <sup>***</sup>	0.26 <sup>***</sup>	0.851

## <The Results of Regression Analysis with Time Lag >

Data set	Influential Factors						Adj. R <sup>2</sup>
	Intercept	Gas	Economy	Oil	Winter	Coal	
<b>Second Phase Data Set</b>	-1.16	0.09 <sup>***</sup>	0.22 <sup>***</sup>	-0.10 <sup>***</sup>	-2.75 <sup>***</sup>	0.09 <sup>***</sup>	0.884
<b>General Data Set</b>	5.66 <sup>***</sup>	0.10 <sup>***</sup>	-	-0.15 <sup>***</sup>	-1.80 <sup>**</sup>	0.24 <sup>***</sup>	0.812

Asterisks indicate the significance levels of estimates:  
\* 10%, \*\* 5%, \*\*\* 1%

- ✓ Since this model has a large number of variables, each data set was analyzed by a [stepwise regression procedure](#) to effectively select independent variables that can explain the dependent variables well.
- ✓ All regression models shows that [oil and coal factor are important factors](#). Also, Summer, PhelixPeak, and PhelixBase factors are removed in all results.
- ✓ Regardless of with or without time lag, [the economic variables were included only in the Second Phase Data Set analysis](#). Because the economic issues, such as the 2008 global financial crisis, have a strong effect only a short period of time.

# THE CARBON PRICE ESTIMATION MODELS

The Second Phase Data Set model without time lag

$$Carbon_t = 0.08 + 0.07Gas_t + 0.2Economy_t - 0.13Oil_t - 3.23 Winter_t + 0.14Coal_t$$

The General Data Set model without time lag

$$Carbon_t = 5.56 + 0.09Gas_t - 0.15Oil_t + 0.26Coal_t - 2.16 Winter_t$$

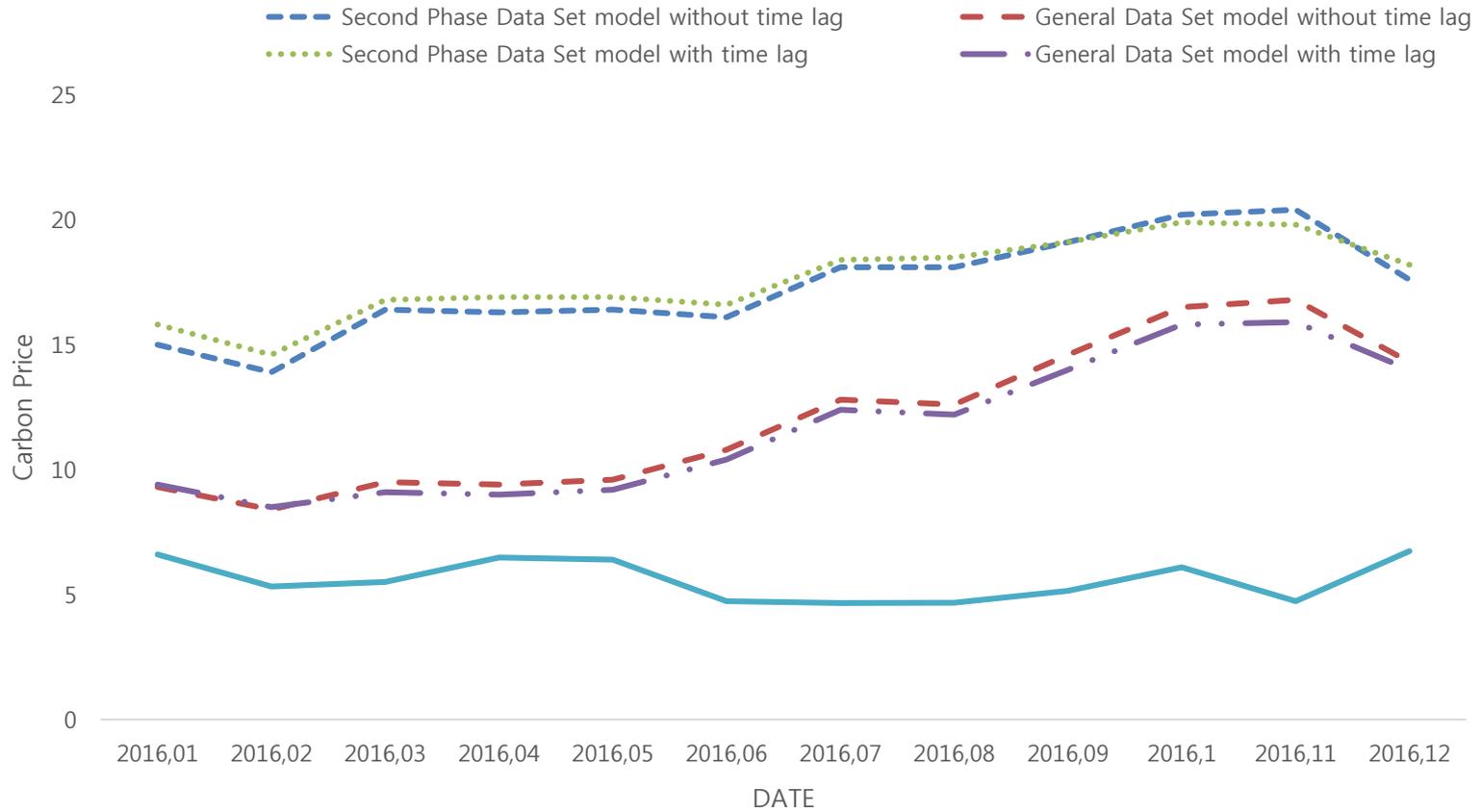
The Second Phase Data Set model with time lag

$$Carbon_t = -1.16 + 0.09Gas_{t-1} - 0.1Oil_{t-1} + 0.22Economy_{t-1} - 2.75 Winter_{t-1} + 0.09Coal_{t-1}$$

The General Data Set model with time lag

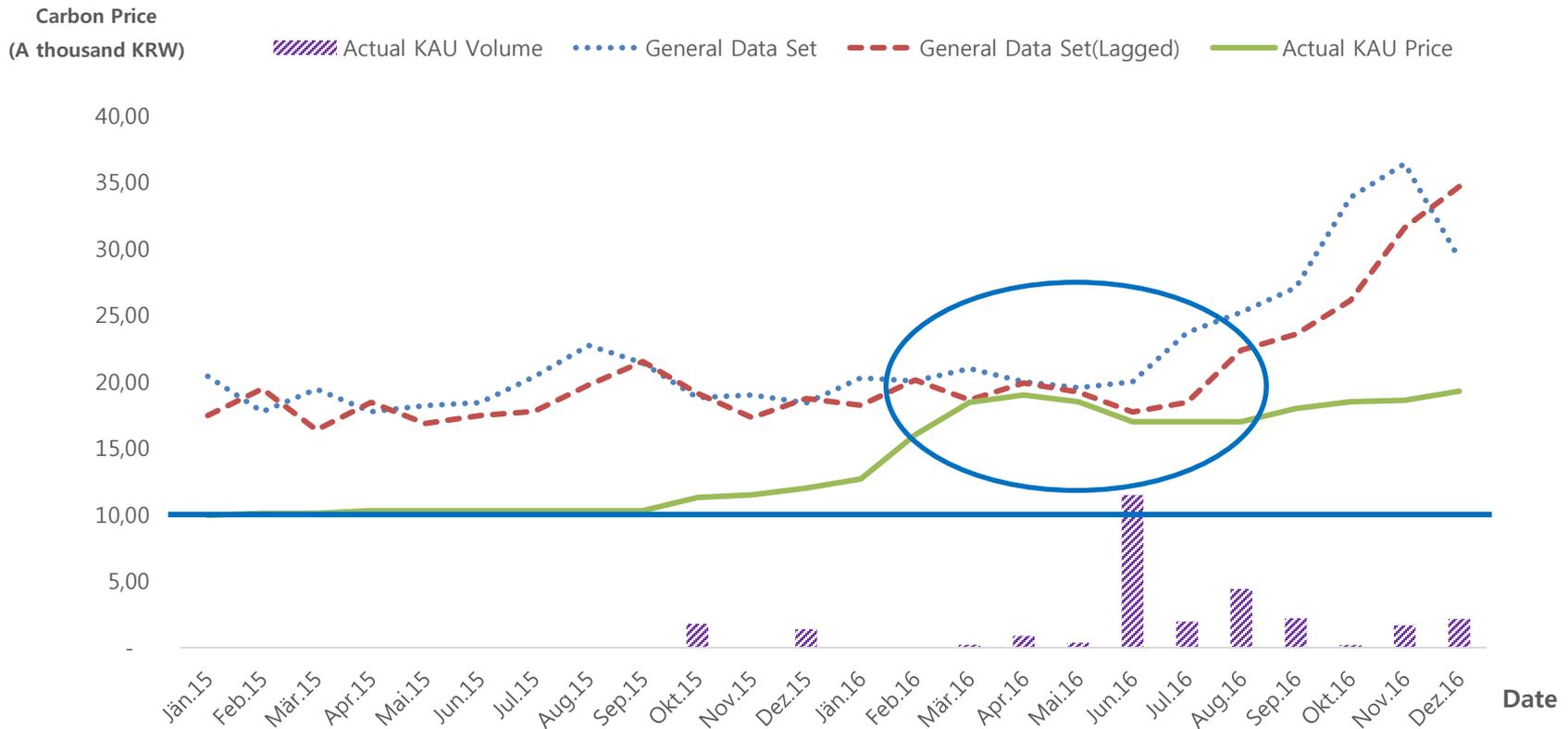
$$Carbon_t = 5.66 + 0.1Gas_{t-1} - 0.15Oil_{t-1} + 0.24Coal_{t-1} - 1.8 Winter_{t-1}$$

# THE MODEL SELECTION



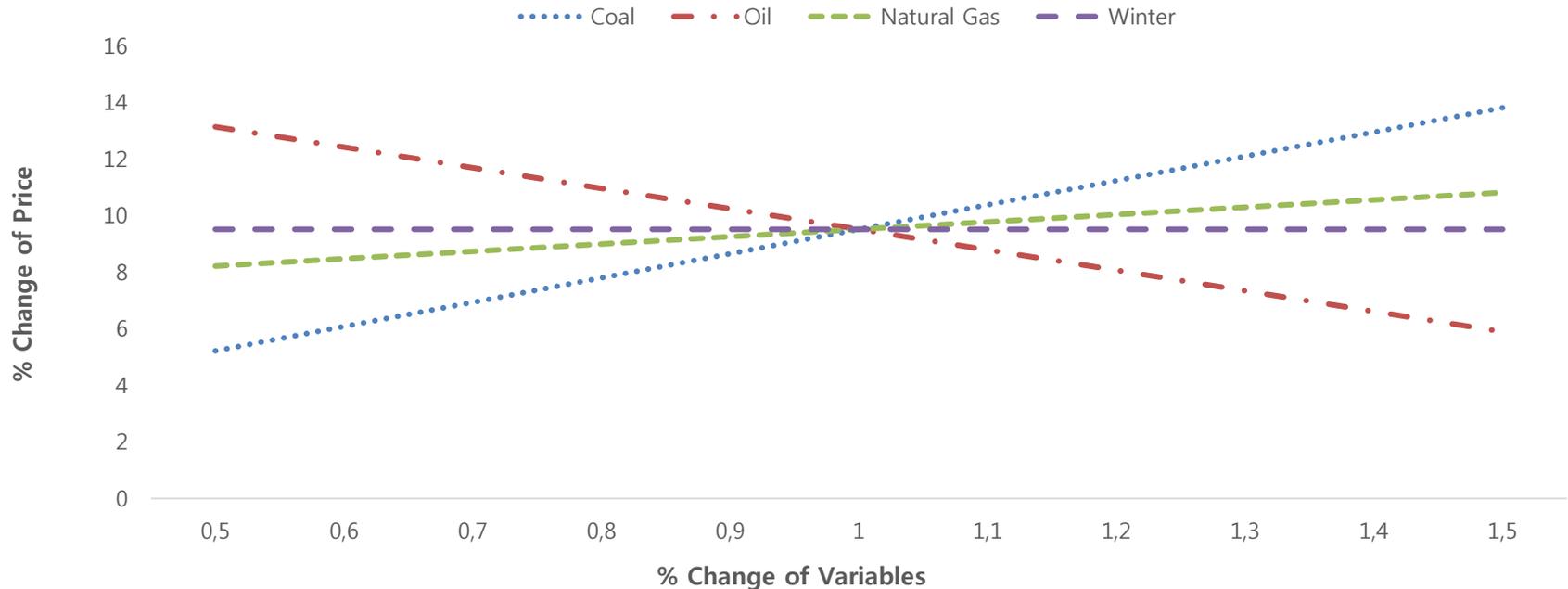
Models	Second Phase Data Set model without time lag	General Data Set model without time lag	Second Phase Data Set model with time lag	General Data Set model with time lag
MSE	142.2	51.3	149.0	45.3

# THE ESTIMATION OF KOREA CARBON PRICE



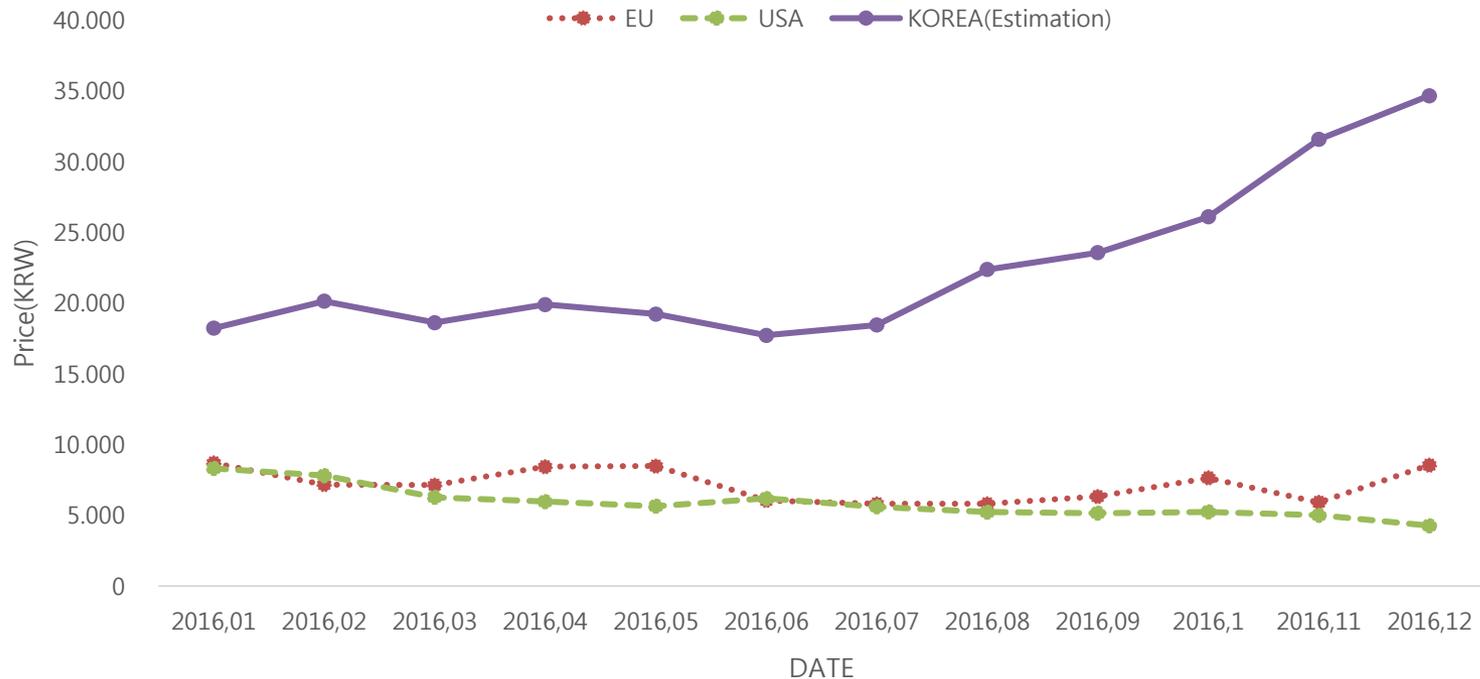
- ✓ For each model, the average Market-Based Korean Carbon Price for 2015–2016 is estimated to be **22,049.87 KRW** for the **General Data Set Model without Time Lag** and **20,458.66 KRW** for the **General Data Set Model with Time Lag**. The both are higher than the current standard price of 10,000 KRW.

# THE SENSITIVITY ANALYSIS RESULT

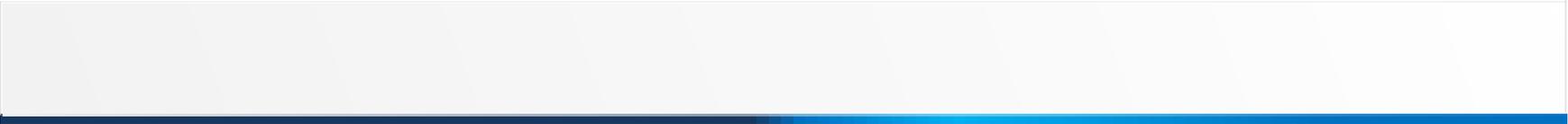


- ✓ The change in the [Estimated Carbon Price of the General Data Set Model with Time Lag in December 2015](#) is graphically shown according to [the each variable is changed by 10%](#).
- ✓ The most sensitive variables are [Coal and Oil](#) with the largest standardization factor in the Carbon Price Estimation Models. Thus, as same with the regression analysis, it can be seen again that coal and oil are the most important variables affecting the Carbon Price in the sensitivity analysis.

# THE COMPARISON ANALYSIS WITH OTHER MARKET



- ✓ Compared with the international carbon market, the Average Carbon Price in the EU-ETS in the same period was 8,926.7 KRW, while the Average Carbon Price in the USA was 6,298.7 KRW while Korea was 20,458 KRW
- ✓ We analyzed the price difference between prices in each countries are originated from the price difference of the influential factors like coal.
- ✓ The Australia Coal price which is usually used in Korea is expensive then the Rotterdam Coal price which is usually used in EU about 60%.
- ✓ As sensitivity analysis result, if we assume there is no coal price difference, then the estimated Korean carbon price will be 7,671 KRW.



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# CONCLUSION

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# COMCLUSION

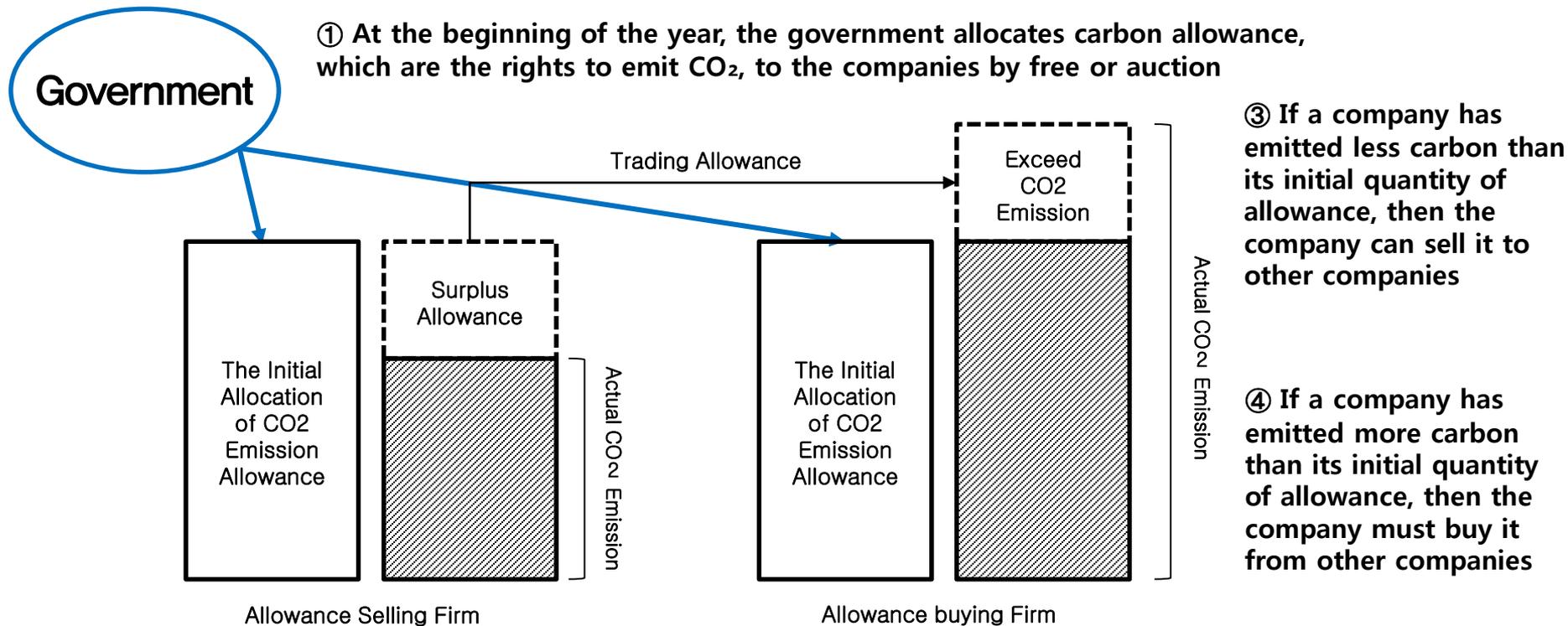
- ✓ This study analysed EU-ETS data, which is the most stable carbon market, and tried to estimate the Market-Based Korean Carbon Price level based on EU-ETS. The major factors affecting the carbon price were selected by literature survey, and the EU-ETS data was analyzed by regression with and without time lag. In addition, we found that the general data set are more predictive than the second data set through the forecasting test.
- ✓ This study is meaningful in that it is the first trial to estimate the appropriate price level of carbon allowance in Korea. Estimated carbon credits price is expected to be used to reset the current standard prices set by government. In addition, the framework and methodology of this study can be used in emerging countries that introduce carbon trading schemes such as China.
- ✓ However, this study has a limitation that we assumed that the Korea shared the same factors affecting carbon emission price with EU market without reflecting the characteristics of each market. Therefore, in future research, it is necessary to improve the model considering the characteristics of each market.

**THANK YOU**

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# CARBON TRADING SYSTEM

## What is Carbon Trading System?



① At the beginning of the year, the government allocates carbon allowance, which are the rights to emit CO<sub>2</sub>, to the companies by free or auction

③ If a company has emitted less carbon than its initial quantity of allowance, then the company can sell it to other companies

④ If a company has emitted more carbon than its initial quantity of allowance, then the company must buy it from other companies

② Companies are doing their business and check their actual CO<sub>2</sub> Emission

⑤ Therefore the carbon emission trading system encourages companies to voluntarily reduce their carbon emissions

# THE SIGNIFICANCE OF THIS STUDY

1. The first trial to derive the Market-Based carbon price for other market.
  2. The first trial to suggest the fair carbon price for activating Korea carbon market considering Korea characteristics.
  3. This study also has significance in that it deals with the latest data, EU-ETS third phase.
- ✓ Most of the previous studies on factors affecting Carbon Price included the EU-ETS first phase data. However, in the first phase, there were special circumstances, such as the collapse of the Carbon Price due to policy deficiency such as excessive allocation and carryover prohibition. Therefore, it is not appropriate to derive a general price estimation model
  - ✓ Particularly, there is insufficient research, including the EU-ETS third phase data, which is the most stable and reflects the latest trend.
  - ✓ Therefore, in this study, we consider second phase data which are the most similar to the Korean market in the main policies such as carryover and free allocation ratio and also consider third phase data reflecting the latest trends.

# ASSUMPTION

In order to estimate the Market-Based Korean Carbon Price through the Carbon Price Estimation Models which are derived from the EU-ETS data, it is necessary to assume that EU-ETS and KETS have same influential factors and the influence level of each factor is also same.

In 2013, Korea, the European Union and the United States have emitted 592.5 metric tons(Korea), 3,411.3 metric tons(EU) and 5,186.2 metric tons(USA) of carbon dioxide. Among them, the proportion of CO<sub>2</sub> emissions from fuel consumption is 96% in Korea, 97.6% in the EU and 99.1% in the US. Therefore, it can be seen that coal, oil, and natural gas, which are representative energy sources, will be common factors affecting the Carbon Price in each country.

According to a study by (H. S. Kim & Koo, 2010), USA carbon market has similar influential factors with EU. Coal in the long term, and coal, natural gas and oil in the short term affects to carbon trading volume in his study. It is similar results with other studies analyzing the EU-ETS.

# EU ETS DATA

DATA	SOURCE
Brent Oil Spot price	IMF cross country macroeconomic statistics
Rotterdam Coal Price	ICE
Henry natural gas index	IMF cross country macroeconomic statistic
Phelix Base	EEX
Phelix Peak	EEX
ESTX50	Yahoo Finance
ECX EUA Future 2012 DEC Price	Intercontinental Exchange Futures Data
ECX EUA Future 2015 DEC Price	Intercontinental Exchange Futures Data
ECX EUA Future 2020 DEC Price	Intercontinental Exchange Futures Data
Weather	World Bank

- ✓ The types of data used in the same factor are [various by researchers](#). Therefore, in this study, we collect [two or three types of data for each factor](#). For choosing the most suitable data, we conducted [correlation test with the carbon price](#).
- ✓ The reason for using futures prices rather than spot prices is that [companies are trading on a weekly basis rather than a daily basis for risk as \(Aatola et al., 2013\) pointed out](#). In addition, [the spot trade accounted for only 10% of total carbon trade](#)(Economics, 2016)
- ✓ All energy and economic data were converted based on [January 2008 data\(=100\)](#) when EU-ETS second phase was started [for smooth application of Korean data](#).
- ✓ The temperature factor was used as [the dummy variables](#), for the three highest and lowest temperature months in Europe presented by World Bank, with reference to (Hintermann, 2010) and (J.H. Baek, H.S. Kim, 2013)

# KETS DATA

CORRESPONDING FACTORS	DATA	SOURCE
Oil	Dubai Oil Spot price	IMF cross country macroeconomic statistics
Coal	Australia Coal Price	IMF cross country macroeconomic statistics
Gas	Henry natural gas index	IMF cross country macroeconomic statistic
PhelixBase	KOREA Electricity Base Price	Korea Power Exchange
PhelixPeak	KOREA Electricity Peak Price	Korea Power Exchange
Economy	KOSPI	Yahoo Finance
Weather	Weather	World Bank

- ✓ The data, which corresponds to each factor [reflecting the characteristics of the Korean carbon market](#), are selected for estimating the Market-Based Korean Carbon Price
- ✓ We selected each data [from analysis of Korea import statistics](#). For example, Oil data is selected as Dubai Oil Spot price. Because it accounts for more than 80% of Korea oil imports.
- ✓ For Korean Carbon Price, we used Korean Allowance Unit spot price at KRX(Korea Exchange). Although we used future price in EU-ETS data, we used spot price for KETS. [Because KETS is not prepared to carbon future.](#)