Modelling and Pricing Air Pollution Derivatives

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# Introduction

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New paragraph: use this style when you need to begin a new paragraph.

# Measuring ambient air quality

## The criteria air pollutants

Millions of people who live in urban areas are victims of severe air pollution. The degree of contamination is determined by measuring the so-called criteria air pollutants. The measurement units for the criteria air pollutants are micrograms per cubic meter (), parts per million (), and parts per billion .

|  |  |  |
| --- | --- | --- |
| Pollutant | Short name | Measurement unit |
| Ground-level Ozone |  |  |
| Particulate Matter 10 |  |  |
| Particulate Matter 2.5 |  |  |
| Carbon Monoxide |  |  |
| Sulfur Dioxide |  |  |
| Lead |  |  |
| Nitrogen Dioxide |  |  |

Table 1. The criteria air pollutants.

## The Air Quality Index

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **AQI** | **O3 (ppb)** (8-hr) | **O3 (ppb)** (1-hr) | **PM2.5 µg/m3** (24-hr) | **PM10 (µg/m3)** (24-hr) | **CO (ppm)** (8-hr) | **SO2 (ppb)** | **NO2 (ppb)** (1-hr) |
| 0-50 | 0-54 | - | 0.0-12.0 | 0-54 | 0.0-4.4 | 0-35 (1-hr) | 0-53 |
| 51-100 | 55-70 | - | 12.1-35.4 | 55-154 | 4.5-9.4 | 36-75 (1-hr) | 54-100 |
| 101-150 | 71-85 | 125-164 | 35.5-55.4 | 155-254 | 9.5-12.4 | 76-185 (1-hr) | 101-360 |
| 151-200 | 86-105 | 165-204 | 55.5-150.4 | 255-354 | 12.5-15.4 | 186-304 (1-hr) | 361-649 |
| 201-300 | 106-200 | 205-404 | 150.5-250.4 | 355-424 | 15.5-30.4 | 305-604 (24-hr) | 650-1249 |
| 301-400 | - | 405-504 | 250.5-350.4 | 425-504 | 30.5-40.4 | 605-804 (24-hr) | 1250-1649 |
| 401-500 | - | 505-604 | 350.5-500.4 | 505-604 | 40.5-50.4 | 805-1004 (24-hr) | 1650-2049 |

Table 2. AQI calculation table

For each of the pollutants, the measured concentration level can be converted into the normalized Air Quality index (AQI) with

(1)

where

– measured pollutant concentration

– concentration level breakpoint

– concentration level breakpoint

– index breakpoint corresponding to

– index breakpoint corresponding to

*Example AQI calculation.* The 24-hour average PM2.5 concentration level is registered at 59 . The corresponding AQI value (rounded to the nearest whole number) is .

# Introducing air pollution derivatives

When faced with severe air pollution in large metropolitan areas, the primary concern is public health. But when ambient air pollution reach extreme levels, the day-to-day activity in the city is also directly affected. (Examples, Spain study, China, ..). Incidents such as these may lead to significant financial losses in the short run. Derivatives contracts such as futures and options are used for risk management in financial markets. There is also a well-functioning market for managing risk arising from non-financial sources, such as weather. Temperature based weather derivatives have been used by the energy industry, the travel industry, and in agriculture for decades.

## Traditional weather derivatives

For a given time interval , a cooling-degree index (CDD) is calculated to measure the need for cooling. The CDD is the cumulative amount of degrees above a pre-specified base level:

(2)

where is the mean temperature for day , and the base level is typically equal to . By taking a position in a CDD future, the holder of the contract swaps a fixed level of the index against the floating CDD. The change in market value for the position will be proportional to the development in the CDD, scaled up by the contract unit size. For example, will a unit size of USD 1 per contract change the value of the future by USD 1 for every unit change in the CDD index. The contracts can cover periods such as weeks, months or seasons.

## Air pollution derivatives

When we evaluate an air quality measurement, we check if a criteria air pollutant is registered above a pre-specified limit, such as the *Hazardous* 300 level on the AQI scale. If this is the case, we calculate the severity of the breach and assign a Pollution Alert Score (PAS). For the time interval , the cumulative Pollution Alert Score is given by:

(3)

# A stochastic air quality model

A seasonal trend function

(4)

Where t denotes the date, and when neglecting leap years.

(4)

# Derivatives pricing

## Air pollution index futures

## Pricing options on air pollution futures

# Empirical results

## Data

## Analysis

# Conclusions

# Acknowledgments

References