Why is Spot Carbon so Cheap and Future Carbon so Dear? The Term Structure of Carbon Prices

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Overview

This study examines carbon spot and futures price relationships and the dynamics of the carbon term structure in the European Union Emission Trading Scheme (ETS) between 2005-2012. In January 2005 the European Union (EU) formally introduced the Emissions Trading Scheme (ETS), a multi-country cap and trade system for emissions of carbon dioxide (CO_2). Under the system a fixed quantity of allowances for emissions are issued each year. Companies covered by the system must submit allowances to match their emissions. The system's Phase 1 (Pilot Phase) covered the years 2005 to 2007, while Phase 2 (Kyoto Phase) covered the years 2008 to 2012. The system is now in Phase 3 covering the years 2013 to 2020. In Phase 1, companies were allowed to bank allowances from one year to the next, but all Phase 1 allowances expired at the end of that Phase. In Phase 2 companies were allowed to bank allowances for use in later years and this banking can continue into Phase 3 and, potentially indefinitely.

It is the banking provision of the ETS that is central to our analysis. The only obvious cost of banking an allowance is the opportunity cost of money. Other commodities have costs of storage, but the cost of holding an allowance is nil; just the overhead involved in managing the electronic account. Other commodities have convenience yield associated with holding the physical good, which reflects the avoided cost of stock-outs or related benefits to the production process. It is hard to imagine a comparable source of convenience yield holding for a carbon allowance. Allowances are submitted annually by the 30th April, after the full inventory of the previous year's emissions is completed and reported by the 31st March. The company has plenty of time to source additional allowances that may be needed. Therefore, a casual analysis of the rules of the EU ETS would suggest that the term structure of carbon prices should be an exact duplicate of the term structure of interest rates, see Parsons et al. (2009). The data, however, contradict this theory.

Methods

Using spot and futures prices, we calculate an implied cost of carry, while using sequential futures prices, we calculate the implied forward cost of carry. Under the rules of the ETS, the cost of carry is - with some exceptions - just the opportunity cost of money, so that the term structure of the cost of carry should exactly equal the term structure of interest rates. We explore the use of the term structure model proposed by Nelson and Siegel (1987). The model is widely used by central banks to model interest rates, see Bank of International Settlements (2005) and European Central Bank (2008). One of the model's advantages is the reduction in the dimensionality of the data, see Diebold and Li (2006). In our case, there is little reduction in dimensionality. However, the model takes the raw time series data, which are defined by a constantly changing maturity and transforms it into a time series of parameters which are consistent through time.

Results

Both our term structure analysis and our individual contract analysis results, consistently point towards evidence counter to theory. However, we show that spot carbon allowances were originally expensive relative to futures, but since late 2008 the situation reversed and spot carbon allowances have been persistently cheap relative to futures prices. That is, the return to holding a carbon allowance together with a short futures position was originally less than the interest rate, but since late 2008 has been much greater than the interest rate. The same result holds throughout the term structure: shorter maturity futures are cheap relative to longer maturity futures. This relationship is puzzling

and deserves attention. It may reveal important facts about market expectations for the evolution of EU ETS rules related to the banking of allowances across years. We fit the term structure of carbon prices to a popular model of the term structure of interest rates, and find a very different structure. Again our term structure analysis points to the *theory* not holding.

Conclusions

The term structure of carbon spot and futures prices has behaved quite differently from what one might have expected from the received theory. The EU ETS allows allowances to be banked from one year to the next, at no penalty, with the important exception of the seam between Phase 1 and Phase 2 at year-end 2007. The cost of storing allowances is miniscule and there is no obvious benefit to holding a supply of physical allowances, as there is for physical commodities. Therefore, the main difference between a spot and future carbon allowance is the opportunity cost of money paid for the spot allowance. That is, the term structure of carbon prices should primarily reflect the term structure of interest rates. However, the data indicates otherwise.

Early in the history of the system, spot allowances were expensive relative to futures. That is, the futures price lay below the cost of carry price defined by the spot price grown at the rate of interest. Then, in 2008, the relationship reversed so that spot allowances became cheap relative to futures. That is, the futures price lies above the cost of carry price defined by the spot price grown at the rate of interest. Futures have remained expensive ever since. The size of the premium is quite large, with futures prices often embodying an implied convenience yield in the neighbourhood of -4% and -6% and sometimes higher. This implied negative convenience yield moves around a significant amount.

This negative convenience yield is an important puzzle. Two potential explanations are the limits to arbitrage and a change in policy that would only affect holders of physical allowances.

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