

**Essays on Energy and Climate Policy -
Green Certificates, Emissions Trading and Electricity Prices**

av

Anna Widerberg

AKADEMISK AVHANDLING

**som med vederbörligt tillstånd för vinnande av
filosofie doktorsexamen vid
Handelshögskolans fakultet, Göteborgs universitet,
framlägges till offentlig granskning
onsdagen den 15 juni 2011, kl 13, i sal E43,
Institutionen för nationalekonomi med statistik, Vasagatan 1**

Göteborg 2011

Abstract

Paper I: An Electricity Trading System with Tradable Green Certificates and CO₂-emission Allowances

Combinations of various policy instruments to deal with the threat of climate change are used throughout the world. The aim of this article is to investigate an electricity market with two different policy instruments, Tradable Green Certificates (TGCs) and CO₂ emission allowances (an Emission Trading System, ETS). We analyze both the short- and long-run effects of a domestic market and a market with trade. We find that increasing the TGC quota obligation will decrease the electricity produced using non-renewable sources as well as the long-run total production of electricity. For the electricity produced using renewable energy sources, an increase in the quota obligation leads to increased production in almost all cases, with assumptions based on historical data. The impacts of the ETS price on the electricity production are negative for all electricity production, which is surprising. This means that the combination of ETS and TGCs gives unexpected and unwanted results for the electricity production using renewable sources, since an increase in the ETS price leads to a decrease in this production.

Paper II: The Impact of the EU Emissions Trading System on CO₂ Intensity in Electricity Generation

The primary objective of EU Emissions Trading System (EU ETS) is to reduce CO₂ emissions. We study the effect of the EU ETS on CO₂ intensity of Swedish electricity generation, using an econometric time series analysis on weekly data for the period 2004–2008. We control for effects of other input prices and hydropower reservoir levels. Our results do not indicate any link between the price of EU ETS and the CO₂ intensity. The most likely reasons to explain this is that emission reductions are generally cheaper in other sectors and that other determinants of fossil fuel use diminish the effects of the EU ETS.

Paper III: Attitudes to Personal Carbon Allowances

A personal carbon allowance (PCA) scheme targets emissions from individual consumption and allocates allowances directly to individuals by dividing the carbon budget on a per capita basis. In this study we analyze the results of a survey sent out to a representative sample of the Swedish population regarding attitudes to a potential PCA scheme. The distinctive design of a PCA scheme is likely to give rise to specific factors affecting individuals' attitudes, such as the perceived fairness of the allocation of allowances and corresponding redistribution of wealth, as well as the perceived complexity of the scheme. We perform an ordered probit analysis with attitude to PCAs as the dependent variable, controlling for a number of variables potentially affecting such attitudes. Interestingly, our findings indicate that the most important variable explaining attitudes to the scheme is the perception of respondents that this type of policy instrument seems very complex.

Paper IV: The stability of electricity prices: Estimation and inference of the Lyapunov exponents

The aim of this paper is to illustrate how the stability of a stochastic dynamic system is measured using the Lyapunov exponents. Specifically, we use a feedforward neural network to estimate these exponents as well as asymptotic results for this estimator to test for unstable (chaotic) dynamics. The data set used is spot electricity prices from the Nordic power exchange market, Nord Pool, and the dynamic system that generates these prices appears to be chaotic in one case since the null hypothesis of a non-positive largest Lyapunov exponent is rejected at the 1 per cent level.

Published in Physica A

Paper V: Market structure and the stability and volatility of electricity price

By using a novel approach in this paper, (λ, σ^2) -analysis, we have found that electricity prices most of the time have increased in stability and decreased in volatility when the Nordic power market has expanded and the degree of competition has increased. That electricity prices at Nord Pool have been generated by a stochastic dynamic system that most often has become more stable during the step-wise integration of the Nordic power market means that this market is less sensitive to shocks after the integration process than it was before this process. This is good news.

Published in Energy Economics

Key words: Attitudes, Carbon dioxide, Carbon intensity, Climate change, Electricity, Electricity prices, Emissions trading, Emissions allowances, Environment, Fairness, GARCH models, Lyapunov exponents, Market structure, Personal carbon allowances, Public opinion, Reconstructed dynamics, Stability, Tradable energy quotas, Tradable green certificates, Volatility

JEL Classification: C14, C22, D12, D21, D24, D43, D60, H23, Q48, Q54, Q56, Q58

ISBN: 978-91-85169-63-4

Contact information : Anna Widerberg, Department of Economics, School of Business, Economics and Law, University of Gothenburg, Box 640, 405 30 Gothenburg. E-mail: anna.widerberg@economics.gu.se