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Time variation in European carbon pass-through rates in electricity futures prices

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HIGHLIGHTS

- We analyse the time-variation of the emission pass-through rate in power prices.
- We examine historical futures prices for Germany and the U.K.
- We test the hypothesis by using the Kalman Filter methodology.
- Strong support is found that pass-through rates vary over time.
- The chosen time-frame for pass-through rates is important for policy evaluation.

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ABSTRACT

The European Union Emissions Trading Scheme is a means to price emission allowances. Electricity market prices should reflect these market prices of emission allowances as they are a cost factor for power producers. The pass-through rate is the fraction of the emission allowance price that is passed through to electricity market prices. It is often measured and presented as an average or a fixed estimate over some time period. However, we expect that the pass-through rates should actually vary over time as electricity supply curves reflect the marginal costs of different producers that differ in emission intensity. We apply a Kalman Filter approach to observe pass-through rates in Germany and U.K. and find strong support for time varying instead of fixed pass-through rates. Although policy makers are interested in the impact of a policy on average, our results indicate that one needs to be careful with the time-frame over which pass-through rates are measured for policy evaluation, as an incorrect chosen evaluation period could cause an under- or overestimation of the pass-through rate. In addition, our model helps to provide policy makers with insight in the development of pass-through rates when market circumstances change with respect to power production.

1. Introduction

The introduction of the European Union Emissions Trading Scheme (EU ETS) introduced a fundamental change in the marginal cost of electricity production. Emission allowances received a market price and became a marginal cost factor for those power plants which run on polluting fuels. Power plants include these costs while they determine the bidding price of their output. Sold on a market place, it is reasonable to expect that electricity market prices somehow do reflect the price of emission rights. The pass-through rate measures the fraction of the price of an emission right passed through to the electricity market price. A pass-through rate of one implies that the electricity market price reflects the price of emission rights entirely. Stated differently, a one euro increase in the marginal emission cost results in a one euro increase in the market price of electricity. Understanding the pass-through rate is important for energy companies and policy makers. The first needs to have a better understanding of the sensitivity of electricity prices to emission right prices for risk management purposes and to understand future prices as a result of different carbon environmental scenarios and the second needs to observe to what extent the costs of emission rights are passed through to electricity consumers.

In the literature the carbon pass-through rate is quoted as an average, however the marginal pass-through rate is subject to external factors and is not constant. The pass-through rate depends, among others, on the carbon intensity of the marginal

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generation unit setting the electricity price. High carbon emission intensive production technologies have higher carbon pass-through rates in absolute sense (Simshauser and Doan, 2009; Kim et al., 2010; Nelson et al., 2012), but the percentage of carbon cost passed-through to electricity prices is in general higher during peak load periods where gas (less carbon-intensive) is the dominant source of electricity production than off peak periods where coal (carbon-intensive) sets the power price (Sijm et al., 2006, 2008). Apparently the higher the power demand and supply, the greater the carbon cost pass-through. The structure of the power market also contributes to the determination of the pass-through rate. First of all the pass-through rate is higher when demand is perfectly inelastic (fixed demand which is unresponsive to price changes). Secondly when supply is perfectly elastic (constant marginal costs) the pass-through rate is also higher (Chen et al., 2008; Freebairn, 2008; Menezes et al., 2009; Nelson et al., 2012; Sijm et al., 2012). Lastly, market concentration also drives the carbon cost pass-through (Chernyavs' ka and Gullí, 2008a,b; Nelson et al., 2012; Sijm et al., 2012). Chernyavs' ka and Gullí (2008a, b) perform an empirical analysis of the Italian market and apply a load duration curve approach that allows them to examine how pass-through rates depend on the degree of market power and on other market structure characteristics. Their main finding is that market power can greatly decrease pass-through rates in peak hours and the pass-through rate can even be negative. Because of these mixed influences, it is not trivial how to measure the pass-through rate from market prices.

Chernyavs' ka and Gullí (2013) provide a literature overview of the average pass-through rates of emission costs in European electricity wholesale and futures prices in Phase I and II. In Phase I power companies received most of the required EU ETS allowances for free in order to cover their carbon emissions. Passing through the costs of these free allowances to the price of electricity caused windfall profit generation. For Phase I Sijm et al. (2006) find variation in the empirical estimates of carbon cost pass-through rates on wholesale power markets in Germany and the Netherlands between the 60 and 100 percent in 2005 and 2006, respectively. Sijm et al. (2008) extend this analysis for nine European countries in 2005 and 2006 and find carbon pass-through rates between 40 percent and 100 percent, usually higher for peak than for off peak periods. Honkatukia et al. (2008) also consider the first Phase and find that approximately 50–100 percent of a price change in the EU ETS market is passed through to Finnish Nord Pool electricity spot prices. Bunn and Fezzi (2008) focus on the U.K. and German market, for which they measure the pass-through rate dynamically by using an equilibrium model and examine changes of electricity and carbon prices due to shocks in gas prices. They find that, in the long-run, a one percent increase in carbon prices yields a 0.33 percent increase in U.K. and 0.52 percent increase in German power prices; a pass-through rate of 33 and 52 percent. Jouvet and Solier (2013) analyse Phases I and II of the EU ETS and estimate the emission right pass-through rates in power spot prices for 10 European countries during the years 2005–2012. They show that the pass-through rate was high during the first Phase of the EU ETS. The economic crisis and the great market instability that resulted from this explained that no significant evidence of carbon pass-through was found for all investigated countries in 2009. However, over the years 2010–2011 clear evidence of significant pass-through rates is found in some of the countries. The authors also find negative pass-through rates in the first Phase and in the second Phase of the EU ETS. In the first Phase they attribute this to overallocation of emissions allowances and in the second Phase to market instability, due to the economic crisis that began in 2008 and resulted in a reduction in power demand and an increase in power price volatility. These studies examined the pass-through rates in wholesale power prices.

Sijm et al. (2006, 2008) and Jouvet and Solier (2013) focus on carbon pass-through costs in electricity futures prices. Sijm et al. (2006) examine one-year ahead forward power prices for Germany and the Netherlands in the first Phase. The authors estimate the pass-through rate using simple ordinary least squares and various bootstrapping methods and find pass-through rates between 60 and 117 percent in Germany and between 64 and 81 percent in the Netherlands. The estimations show different results based on a part of a time period or taken the period as a whole. According to the authors this could be caused by delays in the market internalising the emission right price, rapidly rising gas prices and higher power prices due to increasing scarcity and/or market power. Sijm et al. (2008) extend this analysis for five European countries and find estimated pass-through rates between 38 percent and 182 percent in 2005 and 2006, respectively. Jouvet and Solier (2013) find clear evidence of pass-through rates in electricity forward prices in the second Phase, in contrast with the findings using spot prices. They explain the difference in results between spot and forward prices by the fact that forward power prices are less driven by short-term events than the spot market.

The pass-through rates vary over specific time periods depending on supply, demand and other external factors, but within a certain time period the pass-through rate is quoted as an average. In case of long-term futures contracts we criticise this fact because the average carbon pass-through rate could highly depend on the chosen time-frame. We argue that the pass-through rate is not a constant parameter but a time-varying one. We discussed before that the pass-through rate also depends on the carbon intensity of the different power plants in the market. Electricity production technologies differ in their carbon intensity and knowing that the market clearing price depends on the costs of the marginal producer, we argue that it depends on the technology of the marginal producer what the exact pass-through rate is. As demand for electricity varies within and over days, we expect different marginal production technologies and therefore different pass-through rates. Fig. 1 illustrates this as it shows an example supply curve for a hypothetical electricity market. The market clearing price of power is determined by the intersection of aggregated demand and supply stacks submitted by energy traders, therefore the price is set at the marginal cost of the production of the last producer in the supply curve that produces the last unit fulfilling demand. Fig. 1 shows the composition of the supply curve having renewables (such as wind and photovoltaic), with low marginal costs, nuclear, coal, natural gas and oil. The latter, which produce power with fossil fuels, have a higher emission intensity and have to purchase emission rights. As aggregated demand can be served by renewables and nuclear sources, we expect no pass-through of emission rights in power prices as these sources do not emit carbon. When coal plants are the marginal producers, we expect the pass-though rate to depend on the carbon intensity of coal plants and similarly we expect pass-through rates to depend on the carbon intensity of natural gas plants when they are the marginal producers. Depending on different demand levels during a day or over days, we expect different marginal producers and therefore different pass-through rates. Fig. 1 shows a stepwise supply curve. In the real-world the steps are less wide, the supply curve is more smoothed, and therefore a relatively small change in demand can result in a different marginal producer and therefore a different pass-through rate. In addition, other factors such as outages, market power, prices of fuels and emission rights can change the structure of the supply curve and therefore the marginal producer and the pass-through rate as well (Sijm et al., 2006; Chen et al., 2008).

Our objective is to examine whether we can find support for our claim of that a dynamic marginal pass-through rate should be