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Exploring interaction effects of climate policies: A model analysis of the power market☆

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ABSTRACT

The effectiveness of climate policy strongly depends on how these measures are implemented. National policy measures may have international spillover effects which partly neutralize domestic emission reduction, while different types of policy measures may offset each other as well. This paper explores the conditions for these interaction effects by using a concise partial-equilibrium two-country model of the electricity market which also includes a system for emissions trading. We find that the international spillover effects not only depend on the integration of electricity markets, but also on the tightness of the emissions-trading system. We show that this tightness is negatively related to the degree the supply of renewable energy is stimulated. We find that the more renewable energy is stimulated, the less domestic reduction in carbon emissions is offset by spillover effects. A more binding cap in the emissions-trading system makes national policies less effective. Hence, if climate-policy measures such as subsidies for renewable energy make the cap in the trading scheme less binding, these climate-policy measures become more effective.

1. Introduction

In order to reduce carbon emissions in the power sector, governments are implementing a set of policy measures. These measures vary from subsidies for renewable-energy techniques to taxes on fossil-fuel electricity production and mechanisms for trading in emission rights. While some measures are taken on national level, others have an international character. Within the EU, the implementation of climate policies is pursued by the European Commission. The Renewable Energy Directive (2009/28/EC), for instance, sets a binding target of 20 percent final energy consumption from renewable sources by 2020. Each EU Member State has to realize the renewable-energy target, but these countries are free to choose their own policies to stimulate deployment of renewable-energy sources. EU countries utilize different measures for this purpose, such as feed-in-tariff subsidies and quota systems (Haas et al., 2010). In addition to this, several countries are considering to impose constraints on conventional power plants, in particular coal-fired power plants (EIA, 2014; EZ, 2015). These measures vary from implementing additional environmental standards (e.g. on fuel efficiency or emissions per unit) making

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it complicated if not impossible for (old) coal-fired power plants to operate or imposing a carbon tax which in particular raise the generation costs of coal-fired power plants. Besides this set of different national policy measures to reduce carbon emissions by the power sector, an emissions-trading system has been implemented on EU level. This EU Emission Trading System (ETS) is the largest cap and trade mechanism for CO_2 emissions in the world. It sets up a cap on the total amount of CO_2 emitted by installations of firms subject to this scheme. This cap is annually reduced in order to realize an overall reduction in carbon emissions. The initial allocation of the cap to participants was initially done by grandfathering, but more and more auctioning is used as allocation method (European Commission, 2012). In the secondary market, participants can trade in permits which results in a carbon price. Meanwhile, the European Commission is promoting the integration of national electricity markets to facilitate border-free trading across Europe, see (Keay, 2013). As a result, national power markets have become more closely integrated with each other, which may increase the international spillovers of national climate policies.

It is well established in economic literature that the coexistence of different types of climate policies may have counteracting effects (Schmalensee, 2012; Goulder, 2013; Böhringer et al., 2016). This holds in particular when a cap-and-trade emissions scheme is implemented. In that case, theoretically, the level of emissions is only determined by the cap in the emissions-trading scheme (Tietenberg, 2006). If the cap remains the same, other instruments only affect the costs of reaching that target, but not the amount of emissions. If an emissions trading scheme is combined with subsidies for solar panels, for instance, it can be expected that the emissions within the power sector are reduced which lowers the overall demand for and, hence, the price of emissions permits, which in turn can stimulate other firms participating within the emissions trading scheme to raise their emissions since emitting has become cheaper (see e.g. van den Bergh et al., 2013; Böhringer and Rosendahl, 2011). This effect is called the waterbed effect of climate policy.

In this paper, we explore the conditions for the interaction effects to occur. For that purpose, we analyze the interaction of three types of policy measures to realize a transition of the electricity industry based on fossil fuels towards an industry with a lower level of carbon emissions. These policy measures are subsidies for renewable electricity, a carbon tax for fossil-fuel power plants and an international emissions trading scheme. The choice for these three types of policy measures (emissions trading, subsidies renewables and carbon tax) is based on the fact that all three types of measures are currently implemented or discussed, albeit to a different extent in several European countries. In the Netherlands, for instance, the government recently decided to implement a carbon tax on top of the European emission trading scheme and several domestic support schemes for renewable energy in order to realize a minimum price for carbon. In this paper we do not discuss the pros and cons of the individual climate-policy instruments as subsidies, taxes and emissions trading. Although one can discuss which instrument is best equipped to realise carbon reduction in a cost-effective way (see e.g. Aldy et al., 2010), in practice governments use packages of different types of instruments (Hughes and Urpelainen, 2015; Kautto et al., 2012; Del Rio and Mir-Artigues, 2014; Sijm, 2005). Therefore it is also important to understand how they influence each other.

As we want to analyze the interaction among various climate-policy measures, we build a concise stylized model of two connected electricity markets combined with a regional emissions-trading market. In this model, some electricity producers are perceived as strategic players, hence they can exercise market power and influence the wholesale prices. Such a model is fairly well equipped to simulate the situation with a few centralized power producers, as it exists in several European countries such as the Dutch and German electricity market (see also Willems et al., 2009; Mulder et al., 2015; ten Cate and Lijesen, 2004). We take the stochastic nature of both supply and demand into account. Firms base their decisions regarding investments and the dispatch of plants on expected values for weather conditions, load levels and scarcity levels. Including probability distributions for wind and demand allows us to control for the volatility of market conditions in the power market. International trade is based on price-arbitrage opportunities. The size of the cross-border transmission capacity determines the potential magnitude of international trade and, hence, the potential cross-border spillover effects. The two countries in this model differ in size, so we have a large and a small country. Differences in scale of countries are important to consider in order to better assess international spillover effects from policies implemented in the different countries. One may expect that the magnitude of the spillover effects are highest when they originate from a large country and affect a neighboring country smaller in size. As an international carbon permit market is added to the electricity market, the carbon price is part of the variable generation costs of fossil-fuel producers. In addition, countries may implement a carbon tax on electricity producers. In order to also analyze the international spillover effects of different national policies, we assume that the carbon tax is only implemented in one country at the same time. Countries are also able to stimulate renewable-electricity generation by giving subsidies which are financed by a tax on electricity consumption. The model is calibrated to more or less reflect the current characteristics of the German and Dutch power market. The objective of this calibration is just to have a reasonable benchmark for the numerical analysis, not to make realistic simulations of the power markets in these countries. The numerical analysis remains of a stylized nature with the purpose to explore the conditions for the occurrence of interaction effects among climate-policy instruments.

Using the numerical application of our model, we find that combining the three different climate-policy measures, including an emissions-trading system, may have a net effect on the level of carbon emissions, despite of the above-mentioned waterbed effect. This result comes from the fact that the carbon price in the trading scheme has a floor, i.e. it can never be lower than zero. This means that when other climate-policy measures are effective in reducing the demand for permits, they may also neutralize the waterbed effect. Our findings show that implementing national policies on top of an international emissions trading scheme can still be effective in reducing carbon emissions. As a matter of fact, although adding a carbon