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Energy subsidies, structure of electricity prices and technological change of energy use

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ABSTRACT

This paper addresses the impact of the structure of energy prices on technological change in renewable energy sources. It operates on two fields of research that are often not related to each other. Firstly, the increasing interest in environmental economics for the determinants of green technological change, and secondly the impact of government policies aimed at subsidizing energy prices. Recent research claims a positive relationship between energy prices and the number of patents in the fields of energy efficiency. This paper extends this research by investigating the impact of the price structure of electricity on patent counts in 1) renewable energy sources, 2) wind energy and 3) solar power. In nearly all OECD countries in the period 1990–2006 industrial energy users pay a lower price per energy unit than households due, among others, to government subsidy policies. The empirical results show that reducing government subsidies and hence increasing the electricity price of (large) industrial electricity users relative to the price paid by (small) residential users provides a clear incentive to increase inventions as measured by number of patents in the technical fields of solar and wind energy. These results are an important input in the debate on reducing government support to large energy users.

1. Introduction

In environmental economics growing attention can be observed for energy – and hence pollution – reducing innovations (Popp et al., 2009). Technological changes lead to improved energy efficiency of existing energy sources and to increasing use of alternative energy sources. Energy prices provide incentives to energy users to adjust their energy demand. Higher energy prices induce innovations that help to cope with the resulting increased energy costs. Popp (2002) shows that increased energy prices significantly increase patents in technological fields related to improved energy efficiency. A number of other empirical papers report a positive relationship between higher pollution abatement expenditures and higher energy prices on the one hand and green innovation on the other (Jaffe and Palmer, 1997; Jaffe et al., 2002; Johnstone et al., 2010; Lanjouw and Mody, 1996).

The present study builds on this literature and contributes to it by addressing the impact of price structure instead of price levels on energy technology inventions. During the last twenty years, environmental taxes have been introduced in many countries as a means to reduce energy consumption and hence to contribute to a lower level of greenhouse gas emissions. Nevertheless, a common feature of environmental taxes on energy use is that the rate applied to large energy-intensive users is considerable less than the rate applied to small energy users such as households and small commercial businesses. This tax design results in an energy price structure that places most of the burden of the environmental policy on those users that emit the least, which is not in line with the polluters pay principle (UN, 1992). By providing an economic advantage to intensive energy users in the form of lower energy prices, governments maintain subsidizing the energy consumption of the industry.

Therefore, energy and carbon tax design relates to the policy issue of so-called environmentally damaging subsidies (IEA, 2010; van Beers and van den Bergh, 2009). These are subsidies that, despite being aimed at achieving positively valued economic or societal goals such as reducing energy use or reducing poverty, have negative effects on the natural environment. Environmentally damaging subsidies are often not directly but indirectly provided through different tax treatments of different energy users and as such not recognizable as government support. In the case of energy taxes, exemptions to large energy users seek to avoid possible negative effects on the competitiveness of domestic industries due to the expected increase in production costs. Although studies show that the effect of environmental policies and environmental taxes on competitiveness is small or statistically insignificant (Ekins and Speck, 1999; Enevoldsen et al., 2009), politically it is not viable to push for environmental policies that are believed to harm regional, sectoral or national economic performance.

Different energy users pay different energy prices. But different energy users also have different opportunities to innovate in order to encourage

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use of renewable energy sources. For example, industrial energy users generally have more innovation opportunities – e.g. financial means, collaboration in innovation networks, – to innovate than residential ones. The central argument in this paper is that higher energy prices for large industrial energy users relative to the price paid by small household users stimulate innovations in renewable energy technologies. The policy implication is that taxes and subsidies leading to unequal treatment of different energy users should be reformed in order to encourage technological change towards cleaner energy use.

In the next section the central argument will be discussed. Section 3 introduces a model relating the structure of energy prices to patent output. Twenty OECD countries in the period 1990–2006 are the units of analysis. The econometric results are reported in section 4. The final section provides conclusions.

2. Differential energy prices and technological change

2.1. Differential energy prices

Energy prices are influenced by demand and supply in the global energy markets and domestic policy interventions like regulations, taxes and subsidies. Domestic support for energy prices is provided for five main reasons (IEA, 2010: 571). The first one is alleviating poverty, as energy subsidies are a means of providing access to fossil fuel energy for the poor instead of biomass. Second, fossil fuel energy subsidies are an instrument to stimulate domestic fuel production and hence to reduce dependence on energy imports. A third reason is valid for energy producers and aims at redistributing national resource wealth and stimulating the diversification of the economy and domestic employment by improving competitiveness of energy-intensive basic industries like petrochemicals. Protecting domestic (regional) employment is the fourth reason for governments to subsidize fossil fuel energy use. The final reason is environmental protection and refers to subsidies to renewable energy use in order to stimulate clean energy production and new technologies.

The main purpose of energy and carbon taxes is to reduce greenhouse gas emissions. The resulting increase of energy prices leads to lower demand through improved energy efficiency. In many OECD countries fossil fuel energy prices are taxed but at the same time also subsidized for specific groups of energy users through tax exemptions and tax design. In other words, not all users share the same tax burden. On average, small energy users such as households pay twice as much for electricity per kilowatthour (kWh) and natural gas per cubic meter (m^3) than large-scale users such as energy-intensive industries (IEA, 2008).

In theory, in addition to the benefits brought to the environment, energy and carbon taxes can increase employment if introduced as part of reforms that shift tax burdens from labor income to emissions. Energy and carbon taxes were assumed to have the potential to both reduce emissions in the long term and increase employment in the short term (Pearce, 1991). With this idea of a double dividend in mind, and pushed by EU and other international agreements to reduce emissions in the OECD area, tax reforms took place in a number of industrialized countries since the 1990s (Skou Andersen and Ekins, 2009). Policy makers have raised concerns about the resulting higher production costs due to the carbon and energy taxes that would reduce competitiveness of domestic industries. Environmental taxes can harm energy-intensive sectors by making them pay more than foreign competitors therefore pushing firms to go bankrupt or relocate to places with less strict regulations (Gerald and Scott, 2007). In order to mitigate the negative competitive effects of higher energy taxes, domestic support for energy-intensive firms is provided by means of energy tax exemptions to large (industrial) energy-intensive users such as the steel and chemical firms. These pay a lower average tax per unit of energy than small energy users like households. They also have individual negotiation power towards the energy suppliers, which depresses their energy input price as well. Another reason why most of the burden of energy taxes lies on households is the governments' strategy of shifting taxes from goods to bads (Ekins and Speck, 1999). Because of environmentally based tax reforms in many OECD countries, households pay more for pollution of energy consumption but are compensated through lower income taxes.

2.2. Technological change

There is a growing body of empirical literature on the relationships between environmental policies and innovation (for a review see Popp et al., 2009). Several authors have found a positive relationship between pollution abatement expenditures and research and development spending (Jaffe and Palmer, 1997) and patenting in related technology fields (Lanjouw and Mody, 1996). The stringency of environmental policies has also a positive impact on the technological change of environmentally friendly technologies (Jaffe et al., 2002; Vollebergh, 2010). De Vries and Withagen (2005) found that strict environmental policy on SO_2 leads to more patent applications in relevant technologies for thirteen OECD-countries and Poland in 1970–2000. Several studies argue that innovations resulting from tighter environmental regulations will lead to competitive advantages over firms in foreign countries not subject to similar regulations due to new technological developments and first-mover advantages (Porter and van der Linde, 1995).

Stringent environmental policies lead to higher (shadow) prices of the polluting inputs for the emitter, which provides an incentive to use another less polluting production factor. The theoretical notion that relates the increasing costs of a production factor to substitution towards another production factor was laid by Hicks (1932). A change in the relative price of a production factor spurs innovations that lead to cheaper alternatives for the more expensive input. With regard to this concept of induced innovation a number of studies have explored the role of energy prices in encouraging innovation of energy saving and renewable energy technologies. Newell et al. (1999) focused on the impact of rising energy prices on commercialization of new energy saving technologies and found that energy prices induced innovation of energy efficiency home appliances more than regulatory standards in the period between 1958 and 1993. Using American data for the period 1970 to 1994, Popp (2002) found a strong significant effect of energy prices on innovations in energy technologies pertaining to energy efficiency. Interestingly, most of the effect of energy prices occurs within a few years and then fades away, which suggests diminishing returns to R&D. Recently, Johnstone et al. (2010) examined the effect of different environmental policies on innovation in renewable energy technologies between 1978 and 2003 in 25 countries. An important finding of this study is that different policies such as feed-in tariff levels, investment incentives, tax measures or participating in the Kyoto protocol have mixed effects on the development of renewable technologies such as solar, waste to energy and wind energy.

Until yet not much attention in this literature has been paid to the notion that different energy users have different opportunities to innovate. Therefore, it is important that incentives to innovate are given to users that have most opportunities to innovate. This potential depends on whether energy users are able to innovate themselves directly or indirectly by inducing new inventions and innovations through cooperation with other parties. If energy systems have a decentralized application like for instance roof solar power panels, energy users will be able to introduce innovations much easier than when they are dependent on supply through a grid, like for instance thermal or wind energy. This comes with costs and time and is related to the discussion on technological lock-in mechanism (Arthur, 1989; David, 1985). Then it is necessary to collaborate with the energy supplier, as the inventions required should be introduced at this stage of the value chain. Large-scale energy users have more individual negotiation power than small-scale energy users towards energy suppliers, which creates opportunities to induce energy producers to introduce inventions required for increasing the use of clean energy sources. Moreover, the innovation economics literature suggests and reports strong empirical evidence in favor of the argument that innovations in industrial firms are developed in collaboration with other partners in the value chain like suppliers, competitors,