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Analysis

Regional Net Impacts and Social Distribution Effects of Promoting Renewable Energies in Germany

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ABSTRACT

This paper concerns the net effects of promoting renewable energies on value added and disposable income in Germany, as well as their distribution among regions and income brackets. Since its entry into force, the German Renewable Energy Sources Act (EEG) has stimulated tremendous investments in renewable energy capacities by guaranteeing investors a fixed price per kWh as well as a preferred feed into the grid over electricity from conventional sources. The policy measures are financed by a surcharge on electricity prices. In recent years, a controversy has arisen about potentially negative regional and social distribution effects. In this paper, multiregional price and quantity input-output models with endogenous heterogeneous households are used to trace the indirect impacts of the EEG on value added and disposable income through the complex network of regional value chains. Our findings suggest that the generation of electricity from renewable sources itself leads to small positive impacts on industries, but leads to a significant drain on household income and has regressive distributive effects. However, investment in new capacities may possibly transform these negative impacts into a positive direction for the majority of households.

1. Introduction

This paper has two objectives. Firstly, to examine the regional distribution of *net impacts* of the promotion of renewable energies on industries and households in Germany's 16 federal states. The second objective is to analyse the effect on the distribution of *disposable income* among the income brackets. The term 'net' is used to indicate that this study goes beyond the assessment of *impacts* of demand expansions caused by the production and operation of RE power plants in Germany, which always delivers positive ('*gross*') *impacts*. Instead, offsetting negative *impacts* due to the financing of the promotion and the crowding-out of fossil-based electricity and investment into conventional power plants are explicitly into account. Therefore, *net impacts* result from accounting for these opposing effects.[2]

Since its entry into force in March 2000, the German Renewable Energy Sources Act (EEG) has stimulated tremendous investments in renewable energy (RE) generation capacities, which has led to an increase in the share of renewables in the total generation of electricity to more than 27% by 2014 according to the federal statistical office of Germany (Destatis). The EEG encourages investments into RE capacities by guaranteeing a fixed price per kWh (so-called feed-in tariff) for 20 years, as well as preferred feed-in over electricity generated from non-renewable sources. The difference between the guaranteed price to suppliers and the actual spot market price constitutes a subsidy that is financed by a surcharge per kWh consumed. Companies who fulfil the legal criteria for being considered as energy-intensive pay a drastically reduced surcharge.

In this paper, these policy measures are broken down into a number of positive and negative *direct impacts* on regional households and industries. Thereafter, we trace their wider economic *impacts* on production and income levels, as well as on consumer prices and wage rates through the networks of spatially dispersed value chains. To this end, the analysis is carried out by means of *extended* (i.e., type-II) *multiregional price* and *quantity input-output models*, which are based on a novel multiregional input-output (MRIO) table for Germany's 16 federal states (Többen, 2014) extended with detailed labour force and household accounts depicting the generation, distribution and expenditure of private income among ten income brackets per region.

This study is, to the best of our knowledge, the first to explore regional *net impacts* and social distribution effects of the EEG in a general equilibrium context. The existing literature on the economic evaluation of the EEG mainly concentrates on its effectiveness in encouraging investment in RE capacities and its long-term effects on national GDP and employment (Hillebrand et al., 2006; Butler and Neuhoff, 2008; Lehr et al., 2008, 2011, 2012; Lesser and Su, 2008; Frondel et al., 2010;

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[2] Net impacts should not be confused with 'net-multipliers' (see Miller and Blair, 2009 for an overview). Here, the conventional gross multipliers are used, so that the term 'net' only refers to accounting and comparing positive and negative impacts.

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Langniß et al., 2009). In recent years, however, attention in the public debate in Germany has focused on questions about the regional and social distribution of the costs and benefits of the surcharge and its recycling scheme.[3] Because of different endowments, economic and demographic structures, and regional implementations of national energy policy objectives, the positive and negative effects of the EEG affect regions and sections of the population very differently.

First attempts to study the unintentional effects of the EEG on the distribution of private income focused on the distribution of *direct* costs and benefits stemming from the surcharge and the distribution of revenues for private investors. It is commonly found that the highest financial burden (relative to income) of EEG surcharges is felt by the poorest households (Bardt and Niehues, 2013; Grösche and Schröder, 2014; Lehr and Drosdowski, 2015), which is in line with the general perception about the regressive effects of environmental taxes (Casler and Rafiqui, 1993; Hamilton and Cameron, 1994; Speck, 1999; Wier et al., 2005). For the case of photovoltaics, Bardt and Niehues (2013) and Grösche and Schröder (2014) also show that the recycling scheme of the EEG increases the inequality among households even further, arguing that revenues concentrate on wealthier households, who can afford to invest.

However, these studies do not take the economy-wide repercussion effects into account nor do they consider the regional dimension of economic activity and spillover effects. A notable exception is the work of Ulrich et al. (2012), who use a regional allocation model in conjunction with a national input-output model to examine the regional distribution of gross employment effects linked to the manufacture and operation of RE power plants in Germany's federal states. However, their study does not account for potential offsetting effects caused by the increase in electricity prices, as well as the crowding out of fossil-based electricity and investment in conventional generation capacities. These include, in particular, the increases in the costs of living of households and the costs of production of industries due to the surcharge, as well as economy-wide effects resulting from the replacement of electricity generated in fossil-fuelled power plants. On the other hand, potentially positive effects on private incomes resulting from labour incomes generated by the operation and production of RE power plants and revenues of the owners are also neglected.

The remainder of this paper is organized as follows: The following Section 2 explains the data and main assumptions used to break down the policy measures from promoting renewable energies into positive and negative *direct impacts* on regional industries and households. It also gives overview of the modeling setup through which the respective *total* (*direct* and *indirect*) *impacts* are estimated. A detailed discussion including the derivations of the extended price and quantity input-output models is given in the Supplementary material of this paper. In Section 3, the modeling results are presented and discussed, while Section 4 presents the conclusions.

2. Data and Methodology

The study regions are Germany's 16 federal states. Fig. 1 shows their geographical location and provides additional information about the regional shares in national GDP, population, as well as the proportion of the national total of surcharge payments and feed-in tariffs paid and received, respectively. The year of analysis is 2011.

The ordering of the federal states in official statistics is used here: The first ten states are listed from north to south and constitute those states that were part of West-Germany before reunification (excluding the western part of Berlin). States twelve to sixteen constitute the territory of former eastern Germany (excluding the eastern part of Berlin).

A comparison of the regional shares in national population with those in *national revenues* from feed-in tariffs and surcharge payments reveals some remarkable regional differences. If the state's share of national feed-in tariffs is much lower than its corresponding share of the national population this indicates that the installed capacities of renewables per capita are below the national average. This is in particular the case for the city states of Berlin, Hamburg and Bremen, where the required space for wind and biomass is scarce, as well as for the states of Nordrhein-Westfalen- and Hessen. On the other hand, the more rural states at the coast (SH, NI and MV), the eastern states of Brandenburg and Sachsen-Anhalt and especially Bayern in the southeast receive feed-in tariffs far above their shares of the national population. The states of Niedersachsen and Schleswig-Holstein in the north and northwest as well as the eastern states have large capacities for the generation of electricity from wind and biomass, whereas about 40% and 20% of the feed-in tariffs for photovoltaic and biomass facilities, respectively, are received by operators in Bayern.

Regarding the shares of the states with respect to national *surcharge payments*, a share larger than the corresponding share of the national population is an indication that the economies of these states are based in particular on manufacturing. This is the case in Nordrhein-Westfalen, Rheinland-Pfalz, Baden-Württemberg, Bayern and Saarland located in the west and in the south of Germany, where the majority of Germany's industrial production is concentrated. Compared to that, the economies of Hessen, Hamburg and Berlin depend on services to a larger extent, which results in below average per capita surcharge payments. Below average shares can also be observed in Schleswig-Holstein, Mecklenburg-Vorpommern and Sachsen.

The following subsections first describe how the policy measures of the EEG are broken down into direct impacts on industries and households. Thereafter, it is described how the total (direct and indirect) impacts on *value added* and *disposable income* are derived from the direct impacts by means of extended multiregional *quantity* and *price input-output models*.

2.1. Direct Impacts

The policy measures constituting the EEG have several *direct impacts* on industries and households. Two major channels are examined separately: Firstly, the operation of the existing stock of RE power plants and, secondly, the production of new RE power plants for domestic investment and export. Both channels are associated with different crowding-out effects on conventional power plants: In the first case, electricity generated from conventional power plants is crowded-out, because of the preferred feed-in of electricity from renewable sources. In the second case, by contrast, domestic investments into renewable capacities crowd-out investments into fossil fuelled power plants.

The main reason for treating both channels separately is that domestic investments and, in particular, export demand are only indirectly linked to the measures of the EEG. The eligibility of the feed-in tariff does not depend on whether newly installed RE power plants are delivered from German producers or imported from abroad. For additional information on the main data sources, assumptions and processing steps for the derivation of *direct impacts*, see Appendix 6B.

2.1.1. Direct Impacts of the Operation of RE Power Plants

For the derivation of impacts on industries and households directly linked to the operation of existing RE power plants, the impacts of the individual measures of the EEG are examined. These are, firstly, the direct impacts of the feed-in tariff, secondly, the impacts of the *surcharge on electricity prices* and, thirdly, the impacts of the *preferred feed-in* of renewable electricity, which leads to crowding-out of non-renewable electricity.

The *operation of RE power plants* is promoted through *feed-in tariffs*. Data on region- and technology-specific payments of feed-in tariffs for 2011 are taken from BDEW (2012). These are split into, firstly, *direct* impact through intermediate demand for maintenance and, in the case of biomass, fuel for the operation of RE power plants in Germany, $\Delta \boldsymbol{u}_{RE}$,

[3] A collection of three different contributions to the discussion can be found in Techert et al. (2012).