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LEARNING BY DOING IN THE WIND TURBINE INDUSTRY OR IN WIND ELECTRICITY PRODUCTION – WHY DOES IT MATTER TO DIFFERENTIATE?

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Overview

In economic models of energy or climate policy endogenous technological change is generally introduced through one of two channels, via investment in research and development (R&D) and via learning-by-doing (LBD). Both channels are based on the idea that "knowledge" accumulates in reaction to other model parameters and influences production possibilities (or sometimes also consumption). Only few studies so far have been devoted to implementing learning effects into macroeconomic (top-down) models. They mainly differ as to how cumulative experience is being measured (see for example, Löschel 2002, Gerlagh und Zwaan 2003, Goulder and Mathai 2000) and analyze the effects of learning-by-doing on the optimal timing of climate policy and investment.

Conventionally, learning by doing effects in the renewable energy sector are allocated to the production of renewable based electricity. Our idea is that learning by doing also takes place in sectors that deliver capital (investment) goods to the renewable electricity sector, such as the production of machinery and equipment for renewable energy technologies. Machinery and equipment components have substantially improved over time leading to a higher capacity of individual plants. (Neij et al. 2004). Thus, substantial learning effects have been induced by producing renewable energy technologies and using it to produce electricity. In contrast to the electricity produced by renewables resources, machinery & equipment for renewable energy is highly traded in international markets. In this paper, we introduce learning-by-doing on a sectoral basis in a top-down CGE model. We implement learning-by-doing alternatively in the renewable energy equipment industry and in renewable electricity production and show why it matters to differentiate between these two approaches. The main differences originate from the international trade perspective.

Methods

LEAN_2000 is a two-region empirical general equilibrium model for Germany and the rest of the European Union with a particular emphasis on the representation of the energy markets and the simulation of policies to reduce CO_2 emissions. LEAN is a recursive-dynamic model, which runs over a time horizon of 35 years from the base year 1995 to the year 2030. We implement learning-by-doing alternatively as a function of the cumulative output in a) renewable electricity production itself and b) machinery & equipment used in renewable energy. For the latter, we divide the machinery and equipment sector into a sub-sector ‘machinery and equipment for renewable energy technologies’ and ‘other machinery and equipment’. Both sectors provide investment goods to other production sectors; the renewable equipment sector delivers capital goods to renewable electricity production. We conduct three scenarios and compare them with respect to aggregate and sectoral economic activity, international trade, and energy production and resulting emissions: 1. A base case scenario where no learning takes place in either sector; 2. a scenario where learning-by-doing takes place in renewable electricity production and 3. a scenario where learning-by-doing takes place in renewable energy equipment. Learning-by-doing applies to the efficiency of both capital and labor. In addition, we conduct a sensitivity analysis with respect to spillover effects from Germany to other countries and from other countries into Germany.

Results

Technological progress reduces the costs of renewable energies. When technological progress is induced via learning-by-doing rather than by autonomous efficiency improvement, this may have an influence on the optimal timing of environmental policies and of investment.

Two main effects take place by introducing learning by doing in the renewable energy equipment industry. Firstly, learning by doing leads to a reduction of the unit costs of equipment, which will via capital goods (investment) further translate into reduced renewable electricity costs and prices. The second effect relates to international trade. Learning improves the international competitiveness of renewable energy equipment and stimulates national and international demand for this technology, which then again would induce higher learning (first-mover advantage). An analysis of LBD effects in the production of renewable electricity alone is not able to take account of these international trade effects.

In view of German renewable energy equipment, spillover effects can take place in several ways. For one, Germany can profit from knowledge accumulated outside of Germany. Reversely, knowledge gained in Germany spills over to other countries. Moreover, several regions can simultaneously accumulate experience based on combined efforts to produce a technology. Depending on how such spillover effects are treated substantial effects on domestic production and exports patterns can be observed. Our analysis reveals positive effects of learning by doing on export opportunities and domestic production in Germany. Interestingly, the effect is more pronounced when there is no knowledge spillover either from Germany to other countries or from other countries into Germany.

Conclusions

The analysis shows that it does matter to differentiate between learning by doing in the renewable energy equipment and in renewable electricity production. This is because of international trade effects associated with learning-by-doing in the machinery & equipment sector. Those effects and their stimulation of further production activity and learning get commonly overseen when implementing endogenous technological change in the form of learning-by-doing in top-down energy-environment models. If learning-by-doing affects export sectors and improves international competitiveness this has consequences for the economic assessment of the costs and benefits of climate policy. Further analyses in this area may profit from the literature on international trade and its dynamics in the context of learning by doing (see for example Young 1991).

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