Energy R&D Investments and Emissions Abatement Policy

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Economic models of climate change have attempted to evaluate the benefits and costs of slowing down climate change. Considering the long-term effects of greenhouse gases on climate change, policymakers must take into account the interaction between energy technological progress and emissions abatement policies. This study aims to analyze whether and how energy R&D investments shape energy technological changes. The study considers R&D investments in energy efficiency and in backstop technologies. The former is expected to enhance the level of efficiency in energy supply chains and convey the same energy with fewer carbon emissions. The latter is supposed to expand the system scales of backstop technologies, to speed up energy transitions from fossil fuels to backstop technologies endogenously, and to reduce the amount of carbon emissions in the long-term.

This study develops a new model incorporating energy R&D investments and endogenous energy substitution. The model is built upon two sectors, the capital-goods production sector and the consumption-goods production sector, and four energy resources, three fossil fuels and a backstop technology. The new model has two distinct innovations. First, it adopts a two-factor learning curve to capture the effect of the two R&D investments on energy technological progress. Second, the model develops a two-sector and multi-energy production function with detailed energy representation, which emphasizes the micro-foundation of the energy transition. The study simulates four R&D cases, i.e., without energy R&D investments, only with R&D investments in energy efficiency, only with R&D investments in backstop technologies, and with both R&D investments. Each case considers four CO_2 abatement policies, i.e., business as usual (BAU), an optimal policy, a 2 °C policy, and a 1.5 °C policy.

The simulations show that R&D investments in backstop technologies appear to account for 80% share in the total energy R&D investments. Considering the interactions within the two types of energy R&D investments, R&D investments in backstop technologies crowd out more R&D investments in energy efficiency under the case with a more stringent abatement policy. A more restrictive abatement policy appears to boost the R&D investments in the early period from 2015 to 2050.

The simulations present energy transition progress in the economy. The sequence of the energy transition in the capital goods-production sector is from oil products to coal products, and to a backstop technology while one in the consumption goods-production sector is from natural gas to oil products, to coal products, and to a backstop technology under the BAU policy, the optimal policy, and the 2 °C policy. However, under the 1.5 °C policy the energy transition appears to occur from oil products/natural gas directly to a backstop technology in the capital/consumption goods-production sector. The energy transition to backstop technologies occurs in 2090 under the optimal policy, in 2070 under the 2 °C policy, and in 2050 under the 1.5 °C policy provided two types of energy R&D investments. The R&D investments in backstop technologies appear to accelerate the energy transition to the backstop technology by five years.

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A more restrictive abatement policy appears to hurt the economic welfare more in the short-term, while it appears to enhance the economic welfare more in the long-term. The abatement costs under the optimal policy are one-tenth of those under the 2 °C policy and one-fifteenth of those under the 1.5 °C policy. R&D investments in the backstop technology lead to about 10% gains in GDP under the three abatement policies and reduce the abatement costs by 5% under the 2 °C policy and by 4% under the 1.5 °C policy. The highest temperature is expected to reach 2.65 in 2105 under the optimal policy, which is 0.42 °C lower than one under the BAU scenario.

The study runs the robustness check regarding the learning rate and the time horizon. A high learning rate brings an early energy transition to the backstop technology and results in high economic gains through the R&D investments in the backstop technology. Two time-horizons, i.e., a 100-year horizon and a 300-year horizon, are adopted and examined. The differences between the results of the two time-horizons are small for the relative changes in energy R&D investments, economic gains, abatement costs, and the timeframe of energy transition from 2015 to 2100.