Green energy transition: decarbonisation of developing countries and the role of technological spillovers

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Abstract

Decarbonization of the world's energy sources is necessary within the next few decades to mitigate climate change. In simple terms, first, there should be some form of carbon pricing to internalize the climate externality. Increasing the relative price of fossil fuels leads to a higher demand for renewable energy sources (market effect). Second, more demand incentivizes innovation in renewable technologies with subsequent further increases in their productivity (decline in their relative price, price effect). Market effect and price effect as in (Acemoglu et al. 2012) create the process of green energy transition ultimately leading to the decarbonization of energy sources in the world .
This decarbonization mechanism seems to be working for the advanced countries (with the terms "advanced countries", "advanced regions", and "advanced economies" I cover high-income (HI) and upper-middle-income (UMI) countries from the World Bank country classification by income level). Many advanced countries have some form of carbon pricing in place; a significant reduction in prices for renewable energy sources is observed together with the rise in the share of renewable energy in primary energy consumption. Application of the same decarbonization mechanism to the developing countries (with the terms "developing countries", "developing regions", and "developing economies" I refer to low-income (LI) and lower-middle-income (LMI) countries from the World Bank country classification by income level) does not seem to be straightforward for two reasons. First, carbon pricing in developing countries is controversial due to concerns about carbon justice.
Second, as economic growth literature (Aghion and Howitt, 1997) points out, developing countries are not innovating, but rather adopting already existing technology to catch up to the technological frontier through global technological spillovers.

Difficulties with carbon pricing together with the key role of technological spillovers for growth in developing countries create two counteracting forces. On the one hand, in the absence of carbon pricing in developing countries, there is no economic incentive for them to switch from fossil fuels to renewable energy sources. On the other hand, in the case of decarbonization in advanced countries, renewable energy sources are becoming more prevalent and generating more spillovers, substituting for fossil fuel technologies in developing countries even without carbon pricing. Given that developing countries do not have well-established energy infrastructure that relies on fossil fuels, they may have a chance for an easy transition to renewable energy for sustaining growth.

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This motivates the research questions of the present paper. First, this paper investigates the role and the quantitative impact of technological spillovers on decarbonization in developing countries. Specifically, it aims to determine (i) whether a "renewable energy path" can be established in the presence of spillovers without carbon taxation and (ii) whether a "fossil fuel path" could emerge if there are high spillovers in fossil fuels. Secondly, the study seeks to understand how advanced economies can influence the decarbonization process in developing countries if technological spillovers are at play. It explores the most effective and efficient policy measures that can be implemented. This includes considering whether (i) advanced economies should subsidize innovation in renewable technologies to influence spillovers, (ii) intensify green technological spillovers through technology transfer subsidies, or (iii) regulate the transfer of fossil fuel technology.

To address these questions I develop a two-region integrated assessment model of the global economy and climate with two energy sources (fossil fuel and green energy). The simpler version of a setup incorporates advanced and developing economies, with an advanced economy featuring exogenous growth in energy inputs and a developing economy relying on technological spillovers for the growth in both energy inputs. This setup helps to answer the first set of questions of the paper. To answer the second set of questions I endogenize the growth in final goods as well as in energy sources in the advanced region and make the rate of spillovers a policy variable. The second modeling set-up is still a work in progress.

The model belongs to the class of DICE-like models as in (Nordhaus 2017), and particularly relies on (Golosov et al. 2014) and (Dietz and Lanz, 2019) in terms of the economic part and on (Folini et al. 2023) in terms of the climate part. The first novelty of the model comes from coupling fossil fuels and renewable energy sources in the economy with the three-reservoir carbon cycle and with two-reservoir temperature in the climate emulator. The second novelty is that the model explicitly features developing economy and technological spillovers. In solving this model I rely on a novel deep learning algorithm for global solutions suggested by (Azinovic et al. 2022). This method is especially suitable for large-scale highly non-linear dynamic optimization problems and this paper is the first one to apply it to the multi-region integrated assessment models which makes up for the third, computational, novelty of the paper.

The main finding of the paper is that the presence of technological spillovers in developing countries leads to faster growth of renewable energy, resulting in increased substitution for fossil fuels. This result highlights the positive impact of spillovers on decarbonization efforts. Additionally, the study suggests that implementing carbon taxation in both advanced and developing regions in conjunction with technological spillovers still yields the most favorable outcomes for the climate. However, it is worth noting that the absence of carbon tax in developing countries with spillovers still delivers slightly better environmental results compared to taxation of both regions without spillovers.
These results emphasize the importance of considering both spillovers and carbon taxation in designing effective strategies for achieving environmental goals. They motivate further work in extending the current model with endogenous growth and endogenous spillover rates to understand how advanced economies can influence the decarbonization process in developing countries through technolgical spillovers.

Keywords: Green energy transition, developing countries, decarbonisation, integrated assessment modeling, technology spillovers