Why Stop at Net-Zero? Breaking the Zero-Lower-Bound on Emissions

Why should a country limit its climate strategy to net-zero carbon emissions? Suppose a country hits net-zero. The threat of climate damages will remain, so the country should be willing to pay to mitigate damages; however, without a way to break the zero-lower-bound on emissions inherent in traditional green technologies, the country will have no channel to satiate its willingness to pay (WTP). One solution is for net-zero countries to pay for abatement abroad. But the rise in nationalism makes such a transfer infeasible. The only alternative is a negative emissions technology (NET)—for example carbon sequestration.[1] NETs would enable countries to continue the fight against climate change after reaching net-zero. I will study: what is a country's optimal level of investment in research on NETs given the technology's unique attribute of removing the zero-lower-bound on emissions? Since this zero-lower-bound is more likely to be constraining for wealthy countries, who are also disproportionate historical polluters, climate strategy that looks beyond net-zero could decrease the unfairness created by polluters not internalizing the negative externalities of their historical pollution.

Motivation

Countries do not internalize the negative externality of their pollution, which creates a classic public goods problem. Emerging frictions—rise in nationalism, anti-immigrant sentiment, trade conflicts, and war—mean the world is increasingly stuck in a non-cooperative equilibrium as described in Nordhaus and Yang (1996). In such a world, although countries may reduce pollution to prevent damages at home, an under-investment in abatement is inevitable. How can countries minimize this under-investment? This under-investment would shrink if countries could fight climate change beyond net-zero.

To break net-zero, a country could pay another country to abate. Since a country's WTP should align with its marginal abatement cost, spatial heterogeneity in WTP means a transfer could be mutually beneficial even before net-zero. For example, the United States could pay Brazil to prevent deforestation of the Amazon. However, such a transfer would be politically challenging. Although the carbon offset market allows companies to pay others to abate it would not be politically expedient for a national government to buy them, even if the offsets were creditworthy. The Inflation Reduction Act (IRA) highlights this infeasibility. It seeks the cheapest ways to fight climate change through subsidies for abatement projects in low-income areas but looks for opportunities only within the borders of the US. Its America-first emphasis inhibits climate progress by, for example, limiting electric vehicle subsidies to cars assembled in North America.

Without international transfers, a NET is the only way to extract climate contributions from a net-zero country. Therefore, developing NETs could improve the inefficient non-cooperative equilibrium. Although NETs currently operate on a small scale, the technology is growing, spurred on by IRA subsidies. Direct Air Capture, which removes carbon from the atmosphere, is commercially available. A related technology, Carbon Capture and Storage, which captures carbon released by a power plant and would be a NET if the plant burned biomass, has over 1500 active projects. ExxonMobil, the largest participant, captures 9 million metric tons of carbon per year, which is equivalent to the amount of carbon emissions saved by the world's solar capacity in 2008. Solar has grown more than 40 times since then.

Intellectual Merit

I explore a novel example of how the characteristics of a technology can improve non-cooperative behavior in a public goods setting. Although previous studies have tried to measure expected

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[1] Carbon capture is an example of a NET except when used to capture emissions from burning fossil fuels. Direct Air Capture and Bioenergy with Carbon Capture and Storage are two examples of carbon capture that are NETs. Tree-planting is a NET.

technological growth in NET, they do not account for the crucial characteristic of NET that it better satiates regional heterogeneity in WTP to prevent climate damages. My work will build on empirical research by Cruz and Rossi-Hansberg (2024), which shows that WTP is highly spatially heterogenous and is concentrated in warm, wealthy regions. I argue that this regional heterogeneity intensifies the need to look beyond net-zero, which is currently rare in integrated assessment models (IAMs).

Methodology

I will construct a regional IAM to answer the question: given that net-zero countries can only fight climate change using NET, what is a country's optimal allocation of research dollars between traditional green technology and NET? I will calibrate the anticipated technological growth in NET.

In the model there are multiple countries. Each country is endowed with varying initial productivities and has a representative household that consumes a final good. Each country has three technologies—brown, green, and NET—whose productivities grow with research investment and are modeled like the sectors in Acemoglu et al. (2012). The brown technology produces final goods but creates pollution; the green technology produces final goods without polluting; and the NET lowers the carbon stock but does not create final goods. Countries can invest in research in the three technologies, which increases their productivities. Technological growth partially spills over to other countries. Similar to Acemoglu (2012), investment in research has a probability of success, which I calibrate. Countries maximize their own welfare, which includes consumption and climate damages. This selfishness creates a public goods problem as countries do not internalize the negative externality of their pollution.

Due to the uncertainty in the feasibility of NET, the main empirical task is to accurately measure the growth rate of its productivity. I will measure the probability that a research grant in a given energy technology turns into a patent by the maturity of the energy technology, similar to Akcigit and Kerr (2018). I will match grant data from the Small Business Innovation Research program with patent data from the United States Patent and Trademark Office. I will implement a logistic, grant-level specification:

$$Prob(Patent_i) = f\left(\beta_1 Prod_{i,Tech} + \beta_2 Grant\ Size_i + \gamma_{Tech} + \delta_{Year}\right) + \epsilon_i$$

Where $Patent_i$ is the probability that grant i turned into a patent. $Prod_{i,Tech}$ is the total historical energy production of the technology (in logs) when the grant is given. $Grant\ Size_i$ is the dollar amount of the grant (in logs). The year fixed effects, δ_{Year}, control for trends in the patent and grant systems. The technology fixed effects, γ_{Tech}, will pin down the relative likelihood of innovation success between the green, brown, and NET technologies.

Broader Impact

Modeling NET's ability to draw out WTP from net-zero countries will help improve the allocation of investment in research between green technology and NET, thereby reducing the inadequacy of the response to climate change. Without a concerted international effort to make countries pay for their historical externalities, disproportionate historical polluters will continue to free ride. Since wealthy countries developed before current green technology was available, they are more likely to be disproportionate historical polluters. Since these disproportionately-polluting, wealthy countries are also likely to reach net-zero more quickly due to their higher WTP, NETs will encourage greater contributions from these countries, reducing the unfairness created by their free riding.

References: **[1]** Acemoglu, D., Aghion, P., Bursztyn, L., and Hemous, D. 2012. "The Environment and Directed Technical Change." *American Economic Review*. **[2]** Akcigit, U. and Kerr, W.R. 2018. "Growth through Heterogeneous Innovations." *Journal of Political Economy*. **[3]** Cruz, J.L., and Rossi-Hansberg, E. 2022. "Local Carbon Policy." *NBER Working Paper*. **[4]** Nordhaus, W., and Yang, Z. 1996. "A Regional Dynamic General-Equilibrium Model of Alternative Climate-Change Strategies." *American Economic Review*.