European Economic Review 99 (2017) 191–215

Contents lists available at ScienceDirect

European Economic Review

journal homepage: www.elsevier.com/locate/euroecorev

Balancing the carbon budget for oil: The distributive effects of alternative policies

Carolyn Fischer[a,b,c,*], Stephen W. Salant[d,e,f]

[a] Resources for the Future (RFF), United States
[b] Fondazione Eni Enrico Mattei (FEEM), Venice, Italy
[c] CESifo Research Network, Germany
[d] Department of Economics, University of Michigan, United States
[e] AREC, University of Maryland, United States
[f] Resources for the Future (RFF), United States

ARTICLE INFO

Article history:
Received 3 June 2016
Accepted 11 April 2017
Available online 15 April 2017

Keywords:
Climate change
Spatial and intertemporal leakage
Innovation
Carbon tax
Cap-and-trade

ABSTRACT

Keeping temperature change below 2°C will require leaving large reserves of fossil fuels unextracted. We assess alternative policies to achieve this goal in a world divided into two regions, one regulated with emissions pricing and one unregulated, supplied by multiple resource pools with different extraction costs and a carbon-free backstop whose costs decline over time. Global emissions can be reduced by combinations of three policies: (1) increasing the size of the regulated coalition, (2) raising the tax (or tightening the cap) within the regulated coalition, and (3) accelerating cost reductions of the clean technology. We ask how combinations achieving the same cumulative CO_2 emissions (the "carbon budget") affect the discounted surplus of regulated and unregulated consumers and the wealth of the extractors. We first evaluate these policy alternatives in a two-pool, theoretical model with high and low-cost extractors and, once tradeoffs are illuminated, in a calibrated oil market model. A global CO2 tax is both cost-effective and the best policy for regulated consumers. Extractors and unregulated consumers, however, prefer a technology-only policy. When the regulating coalition is subglobal, support for the clean substitute is desired and often required. But the preferred policy portfolio of the coalition involves a tighter cap and less technology policy than is globally optimal, leaving room for bargaining over who pays for clean innovation.

1. Introduction

In the Cancun Agreements under the United Nations Framework on Climate Change (UNFCCC) Conference of the Parties (COP) 16 in 2010, a global commitment was made to hold the increase in the global average temperature to well below 2°C above pre-industrial levels, to avoid exceeding a threshold beyond which abrupt and irreversible climate change is likely to occur. According to the Intergovernmental Panel on Climate Change (IPCC), to hold global warming to 2°C with a 50% probability, cumulative emissions cannot exceed 1000 gigatons of carbon, or 3670 tons of carbon dioxide (CO_2), starting from the industrial revolution. However, more than half that "carbon budget" has already been emitted, and at current

* Corresponding author at: Resources for the Future, 1616 P Street NW, Washington, DC 20036, United States.
E-mail addresses: fischer@rff.org (C. Fischer), ssalant@umich.edu (S.W. Salant).

http://dx.doi.org/10.1016/j.euroecorev.2017.04.003
0014-2921/

rates, we will reach the limit in the next 30 years (Intergovernmental Panel on Climate Change , 2013; Meinshausen et al., 2009). Estimates of cumulative emissions targets for this century are roughly 1,100 gigatons of CO_2 (Meinshausen et al., 2009), but many times this amount is embodied in available fossil fuel reserves (Clarke, 2014; McGlade and Ekins, 2015). Thus, to keep emissions below this limit, dramatic changes must occur in energy consumption over the next generation and, in the absence of geoengineering or carbon sequestration, large shares of fossil resources must be left unexploited.

The Paris Agreement (UNFCCC COP 21 in 2015) reaffirms the 2° ceiling and lays a framework for emissions mitigation where efforts are not coordinated, but rather pledged unilaterally as nationally determined contributions, of which only a fraction intend to use emissions pricing as a central policy mechanism.[1] The result is divergent levels of ambition among the parties, arising in large part due to the principle of "common but differentiated responsibilities and respective capabilities" (CBDR–RC) embedded in the UNFCCC.[2]

A challenge for reducing GHGs in this setting is that while regulations are subglobal, fossil fuel markets and oil markets in particular are global. If one region reduces its demand for fossil fuels by imposing emissions prices, then the inward shift in global demand would depress the world price of oil, which in turn would stimulate oil demand in parts of the world where carbon emissions are not regulated. Thus, differential carbon pricing results in "carbon leakage."[3]

At the same time, fossil fuels and oil in particular are also scarce resources that are exploited over time. If climate policies make selling fossil fuels in the future less attractive than current sales, suppliers may prefer to extract more in the present, offsetting future emissions reductions. Indeed, current oil prices are well above costs for some of the world's largest reserves, leaving ample room for price reductions if consumers begin switching from heavily taxed fossil fuels to clean, increasingly affordable substitutes. Sinn (2008) popularized this notion of future climate policies accelerating current emissions as the "green paradox."

This paper assesses climate policy options in a world with both spatial and intertemporal leakage. We use a transparent, dynamic, partial equilibrium model inspired by the global market for liquid fuels. We divide the world's consumers into two regions, one regulated with emissions pricing and one unregulated. Suppliers are price-takers and choose wealth-maximizing extraction paths. Their fossil resource stocks are found in separate pools with pool-specific constant marginal extraction costs; as a result, depletion costs are stock-dependent and rise step-wise as lower-cost resources are depleted.[4] A carbon-free backstop technology is available at a cost that is initially higher than all fossil resources, but over time that cost falls and eventually becomes cheaper than even the lowest-cost resource. As a result, at some point each type of consumer will prefer the clean substitute, and policy choices influence that point. The challenge for subglobal policy in meeting a global carbon budget is that even unregulated consumers must be induced to switch to the clean alternative while fossil stocks remain incompletely exploited. Our modeling approach permits us to examine the distributive effects of meeting this challenge using different policy combinations.

We consider three exogenous policies to reduce global emissions: (1) raising the emissions tax or tightening the cap imposed on consumers in the regulated region; (2) expanding (as through international negotiation) the size of the regulated region; and (3) speeding up the cost-reducing technical change in the clean backstop. Although any of these policies can reduce cumulative emissions,[5] they affect extractor wealth and consumer welfare differentially. We show the important distributional consequences of alternative policy options for meeting a global carbon budget in a context of subglobal regulation.

To fix intuition at the outset, we first assume that there are only two grades of fossil fuel in the world, low cost and high cost. We focus on regimes in which the high-cost pool is incompletely exhausted – consistent with a carbon budget that binds before the resource stock constraint – and explore the trade-offs among our three policies. Subsequently, we use a calibrated oil market model to resolve theoretical ambiguities and explore the trade-offs quantitatively.

As we show, given a rate of technological change, an emissions reduction achieved by imposing a low carbon price on consumers in *every* country is superior to the same emissions reduction achieved by imposing a higher carbon price on a subset of the world's consumers. Extractors would prefer the global carbon price because their Hotelling rents are higher. Consumers who remain regulated gain since the lower carbon price outweighs these higher Hotelling rents, resulting in their paying initially lower prices. And although consumers who become taxed are injured, their losses can be fully compensated out of the additional revenue collected from a global price on carbon. Indeed, the allocations in the competitive equilibrium

[1] As of 2016, roughly 13% of global emissions are covered by carbon pricing mechanisms, and the implementation of the proposed Chinese emissions trading system could double this amount. A majority of signatories to the Paris Agreement, representing 56% of global emissions, are planning or considering some form of carbon pricing. (World Bank, 2016).

[2] In the Paris Agreement, this principle was reflected in Article 4.4: "Developed country Parties should continue taking the lead by undertaking economy-wide absolute emission reduction targets. Developing country Parties should continue enhancing their mitigation efforts, and are encouraged to move over time towards economy-wide emission reduction or limitation targets in the light of different national circumstances."

[3] Various studies using *static* computable general equilibrium models (CGE) models have shown the sensitivity of carbon leakage estimates to fossil fuel supply elasticities (Burniaux and Martins, 2000).

[4] Our treatment of depletion effects has a long history that some have traced back to Ricardo two centuries ago (Devarajan and Fisher, 1981); (p. 69). (Solow, 1974), (p. 3) uses this step-wise approach in his Ely lecture. Others take account of depletion effects by assuming instead that the per-unit cost of extraction is a strictly decreasing, differentiable function of the stock remaining. Our conclusion that economic policy can affect cumulative depletion and hence CO_2 emissions does not depend on the way depletion effects are modeled.

[5] Of course, the tax policy has its limits. Once a tax is so high that regulated consumers switch at the first instant to the clean backstop, a further increase in the tax does not affect prices or carbon emissions.