UNIVERSITY OF CAMBRIDGE
Electricity Policy Research Group

Oil Shortages, Climate Change and Collective Action

EPRG Working Paper 1023

Cambridge Working Paper in Economics 1045

David M Newbery

Growing affluence and population are putting increasing stress on the planet's resources, particularly fresh water, agricultural land, forests, biodiversity, key minerals including oil, and the capacity of the oceans and atmosphere to absorb greenhouse gases (GHGs). Two such resources are in direct conflict – fossil fuel and the atmosphere. Burning all of the current estimates of fossil fuel reserves without carbon capture releases CO_2 that would more than double pre-industrial atmospheric CO_2 concentrations. With high probability that would result in global warming of considerably more than 2^0C, with damaging climate changes, as well as ocean acidification. Conventional oil reserves alone do not appear to contain enough carbon to exceed the current target of limiting global warming to 2^0C, but there are growing concerns that conventional oil will soon experience shortages that will not only be disruptive, but may lead to the more rapid exploitation of even more carbon-intensive alternatives. This paper asks what economics can say about oil shortages and their possible consequences, and about the larger question of agreeing collective action to mitigate climate change.

If extraction costs are zero, then the competitive price of oil will rise at the rate of interest. If when oil runs out there is some perfect substitute backstop available, then the price at any date can be calculated by working back from the date of exhaustion, determined by the current stock of oil, and the backstop price. This model can be readily modified to accommodate a sequence of fields of increasing unit production costs. Although it has proven a poor guide to forecasting future oil prices, as prices rose dramatically in 1973 and 1979 before collapsing in 1986, at each date after 1979, analysts used this theory to predict that future prices would rise at something like the rate of interest from then on. The overlay of projected prices on the subsequent actual prices looks like a spiny porcupine with forecasts rising while prices drifted down.

E·S·R·C ECONOMIC & SOCIAL RESEARCH COUNCIL

This model clearly fails to capture important aspects of reality – such as market power and the difficulty of sustaining a cartel by national quota allocations, supply constraints, ambiguities over ownership, the changing balance within OPEC between hawks and doves, surges in exploration and rapid technical improvements in off-shore drilling, the oil-induced recession and inflation of the 1980s, to mention but some. We should not be surprised at the volatility of the spot oil price as it should depend on estimates of future reserves, their cost, the cost of substitutes, and the discount rate, all of which are uncertain and subject to periodic major revision. Nevertheless, the economic argument is clear – oil prices today depend on future developments and particularly the transition from conventional to unconventional oil or other alternatives, as well as being heavily influenced by market structure, and tax policy (which affects demand).

Greenhouse gas emissions are a global stock public bad – emissions anywhere have inescapable global impacts and are persistent, so that there is little difference in the damage done by emissions today and next year. Thus "climate change … is the greatest and widest-ranging market failure ever seen" (Stern, 2006, p i). Current modeling suggests that to have a 50% change of preventing global warming of 2^0C from pre-industrial levels then we can only release another 500 billion tonnes carbon (GtC), compared to past emissions of 500 GtC. The low estimate of conventional oil, gas, and coal reserves are larger than 500 GtC, while exploiting that and unconventional oil and gas would likely raise global average temperatures by 4^0C. The economics of mitigating climate change are therefore relatively straightforward in theory – we need to limit the cumulative emissions of GHGs.

The second economic insight is that under uncertainty it is better to stabilize the price of GHG than the quantity of emissions, because at any moment the marginal damage of emissions is almost independent of rate of emissions, so the marginal benefit of abatement is effectively flat, while the marginal cost of abatement is rising sharply at desired abatement levels. Investors need a credible time path for future CO_2 prices to make rational low-carbon investment decisions. The appendix shows that the price of CO_2 should rise at about the rate of interest in equilibrium, but the current cap results in volatile prices that are currently too low. The EU accepts the need for an 80% GHG reduction by 2050, but only accounts for about 15% of global emissions. Unless emissions limits include non Annex I countries, the likelihood of remaining within the one trillion tonne carbon limit looks small to vanishing.

UNIVERSITY OF CAMBRIDGE

Electricity Policy Research Group

Again economic theory can explain why this is so and what might be needed to avoid the tragedy of the global commons. Each country or bloc is engaged in a prisoners' dilemma – joint agreement would benefit all, but deviation if others abate is doubly profitable, avoiding high domestic carbon prices and hence high manufacuturing costs, allowing exports that undercut energy-intensive manufacturing in compliant countries. Cooperation can be sustained provided players discount the future at a low enough rate and provided there are credible penalties for departing from that agreement – and border tax adjustments to make up for any untaxed carbon in imported goods go some way in that direction.

The impact of carbon taxes on fossil fuel prices can be examined in the Hotelling model of exhaustible resources, with some surprising results. Much depends on the carbon-intensity of the backstop technology and the cost structure of conventional fuels. The appendix shows that if the backstop is zero carbon (e.g. the hydrogen economy), if fuel extraction costs are zero and in instantaneous elastic supply, then a global carbon tax that rises at the rate of interest (as it should) will merely depress the pre-tax price of fuel by the amount of the tax, leaving the post-tax price and the date of exhaustion unchanged. Countries opting out of the climate agreement will enjoy cheaper oil than they do at present and overall emissions will rise – the Green Paradox.

This is an extreme assumption, and Mejean and Hope (2010) have explored a more realistic calibration allowing for uncertainty, and find that between 81-99% of the carbon tax will feed through into the final (tax-inclusive) price of oil, reducing total emissions. In addition there are incentives for governments to impose carbon taxes (with a lower economic cost than most other forms of tax) and hence help resolve the problem excessive volatilty caused by the emissions cap.

While a full analysis of exhaustible resources and climate change is beyond the scope of this paper, its aim is rather to identify the key incentives facing consumers, voters and their governments and the extent to which decentralised market solutions might be used, with corrective carbon taxes, to reach a more satisfactory solution to climate change and resource scarcity.

Contact dmgn@econ.cam.ac.uk
Publication September 2010
Financial Support ESRC TSEC 2

E·S·R·C ECONOMIC & SOCIAL RESEARCH COUNCIL