DEPARTMENT OF ECONOMICS
OxCarre (Oxford Centre for the Analysis of Resource Rich Economies)

Manor Road Building, Manor Road, Oxford OX1 3UQ
Tel: +44(0)1865 281281 Fax: +44(0)1865 281163
reception@economics.ox.ac.uk www.economics.ox.ac.uk

UNIVERSITY OF OXFORD

OxCarre Policy Paper 7

_

Macroeconomics of Sustainability Transitions: Second-best climate policy, Green Paradox, and renewable subsidies

Frederick van der Ploeg

(OxCarre, University of Oxford)

Direct tel: +44(0) 1865 281281 E-mail: celia.kingham@economics.ox.ac.uk

Contribution to *Environmental Innovations and Transitions*, January 2011

MACROECONOMICS OF SUSTAINABILITY TRANSITIONS:

Second-best climate policy, Green Paradox, and renewables subsidies

Rick van der Ploeg, University of Oxford[1]

Fossil fuels like oil or gas may run out in the following fifty years and need to be replaced by renewable sources of energy such as solar or wind energy. Fossil fuels also lead to the emission of CO_2 to the atmosphere, contribute to global warming and thus need to be phased out. Our key question is how to switch from a fossil fuel to a carbon free economy and what kind of depletion paths are optimal from the point of view of both efficient extraction and internalizing global warming externalities.

To answer these questions, it is important to remind ourselves of the pioneering arbitrage insights of Hotelling (1931) about the optimal extraction of fossil fuels. From a descriptive point of view, they state that the market must in the margin be indifferent between, on the one hand, leaving one unit extra of fossil fuel in the crust of the earth and, on the other hand, extracting one unit extra of fossil fuel, selling it on the market, and investing the funds. This implies that the capital gains, i.e., the expected rate of increase in the price of fossil fuel, must equal the market rate of interest. This Hotelling rule also holds if the owner of fossil fuel is a monopolist provided a percentage change in the price of fossil fuel decreases demand for fossil fuel by a given percentage whatever the magnitude of the change (i.e., provided demand is iso-elastic). With extraction costs it is the rent on extracted fossil fuel that should rise at the rate of interest. In the past, oil prices have not risen along a rising Hotelling path but seem to have followed a near random walk (e.g., Hamilton, 2009). Still, as oil reserves are becoming scarcer, the Hotelling argument will gain in strength.

In view of our key question, the Hotelling rule needs to be modified in two respects. First, from the point of view of describing market responses, the rate of increase in the price of fossil fuel will in practice be less than the interest rate. Consequently, the rate of fossil fuel extraction will be lower because the cost of fossil fuel extraction rises as more inaccessible fossil fuel reserves have to be depleted. Rising extraction costs thus mean that fossil fuel is depleted less quickly. Second, taking a normative perspective, if society manages to internalize global warming externalities by introducing a socially optimal carbon tax or realizing an effective market for emission rights based on shadow prices, fossil fuel will be depleted less quickly than in the "laissez-faire" outcome in order to reduce the rate of CO_2 emissions into the atmosphere and curb global warming. This will also lead to a less steep profile of the social price of fossil fuel (i.e., including the carbon tax or the price of the CO_2 permit).

[1] The author is grateful to the Editor and an anonymous referee for helpful comments on an earlier draft. The support of the BP funded Oxford Centre for the Analysis of Resource Rich Economies is gratefully acknowledged.

In view of the transition that society has to face from a fossil fuel to a carbon free economy, the rise in the price of fossil fuel will come to an end when at some point in the future it becomes more expensive than renewables. This moment will come more quickly when there is ongoing technological progress in the production of renewable forms of energy and a consequent gradual drop in the price of renewables as time progresses. The optimal price of energy thus rises during the fossil fuel phase in view of the aforementioned Hotelling logic and once fossil fuels are phased out and renewables phased in the price of energy will gradually fall at a rate equal to the rate of technical progress in renewables. As the moment that fossil fuels are phased out approaches, the difference between the price and the marginal cost falls monotonically to zero (Heal, 1976). Hence, at the moment of the switch to the renewable backstop the price of fossil fuel has become equal to the cost of the backstop.

With these preliminaries out of the way, consider the design of optimal climate policy. Since renewables do not contribute to global warming, the government should not subsidize solar or wind energy and instead punish those who emit CO_2 by implementing a gradually rising price of carbon via a rising carbon tax or a well-designed system of emission permits. Alternative forms of energy which give rise to pollution of the environment, such as coal or the tar sands, should be taxed at a rate equal to the sum of marginal damages incurred by society. There are various reasons why such a first-best policy encounters problems when it being implemented. One problem occurs when governments of the rich countries in the world, who are responsible for most of the carbon debt, raise the price of the carbon unilaterally without rapidly emerging economies such as China and India doing so. What happens then is that the carbon tax will be shifted to OPEC and other producers of oil and gas exporters, and saddling western consumers with rising energy prices, but most importantly Chinese and Indian business and consumers will benefit from lower energy prices and will have higher demand for fuel than without the western carbon tax. The net result of this form of carbon leakage is that global warming is not curbed, but that fuel demand is simply shifted from the west to the east. Of course, the carbon leakage argument results from the incapacity to strike an international climate agreement that corresponds to the global first-best outcome. Carbon leakage rates under the Kyoto Protocol have been estimated to be small, i.e., in the range 5 to 20 percent (Barker et al., 2007). Another problem occurs when governments announce a rising schedule for the carbon tax. In that case, the oil sheiks and other fossil fuel owners have an incentive to pump faster thus rendering climate policy counterproductive as well (Sinn, 2008).

In practice, the political economy of climate policy is such that governments find it very tough to tax coal and have a steeply rising path of carbon taxes (or price of CO_2 permits). This would harm incomes of the lowest paid too much and amounts to political hara-kiri for left-wing parties. Right-wing parties often reject such policies because they succumb to strong, highly concentrated business lobbies. So for climate policy to have a chance at all, one has to resort to second-best policies. This is why many governments offer massive subsidies for renewables when they are too scared of the electorate or business lobbies to implement a rising price of carbon. A good example of this is the enormous subsidy (many times the price of a carbon permit) for using solar in the German electricity industry. But does such a way of subsidizing a transition from fossil fuel to renewables in the absence of a rising carbon tax make sense?

As is almost always the case in economics, the answer is ‘it depends’. Fossil fuel will be fully exhausted at the time of the switch to renewables if the cost of extracting the last drop of fossil fuel is less than the cost of the renewable backstop. In a market outcome which does not internalize global warming externalities in the cost of fossil fuel and thus without the use of an effective carbon tax to regulate greenhouse gases, full exhaustion of reserves is more likely to occur. In that case, subsidizing renewables leads the market to pump up oil and gas and exhaust reserves more quickly and thus to exacerbate global warming damages. This phenomenon has been coined the ‘Green Paradox’ (Sinn, 2008).

However, if a large enough price is charged for marginal global warming damages or in the more likely case that the rate of technical progress in renewables technology is rapid enough, fossil fuel becomes obsolete before reserves are fully exhausted. In that case, subsidizing renewables brings forward the date of the transition from fossil fuel to renewables as before but will also leave a large stock of fossil fuel in the crust of the earth (van der Ploeg and Withagen, 2010a). Hence, the transition to the carbon-free economy occurs more rapidly, less CO_2 is emitted into the atmosphere, and the Green Paradox does not apply. Of course, the pricing of greenhouse gases and technological progress in renewables are not independent, alternative strategies, since a high price of CO_2 (as well as technology-specific policies) encourages the re-direction of technical change towards renewables (Acemoglu et al., 2010).

The above argument against the Green Paradox gains in force when for ethical reasons to do with intergenerational equity a lower discount rate is used to evaluate future global warming damages as in the Stern Review, because then it is socially optimal to leave an even larger stock of fossil fuel in situ and thus to pursue a more aggressive climate policy. Furthermore, the richest societies on our globe have the highest consumption per capita, the lowest marginal utility of consumption and the highest global warming damages evaluated in resource units. They can afford and should therefore pursue a much more aggressive climate policy than poorer societies that are on a development path struggling to survive. Or they should compensate the developing economies to entice them to curb emissions, especially as have they have been historically the biggest contributors to CO_2 pollution.

Of course, there is not one renewable backstop but a continuum of renewable backstops. The rising price of energy will then make it more and more attractive to phase in new renewable technologies as is evidence from examining patent data for the period 1970-94 (e.g., Popp, 2002). The McKinsey Global GHG Abatement Cost Curve (McKinsey, 2010) suggests that switching to LED lighting, improving aerodynamics of cars, electricity from landfill gas and rice management are already profitable and that as the price of fossil fuel rises further reduced deforestation from slash-and-burn agriculture and pastureland conversion, grassland management, organic soil restoration, nuclear, wind and finally solar will become profitable as well. Having a continuum of backstops makes it optimal to first have a phase where only fossil fuel is used, then a phase where fossil fuel is used and more and more expensive renewables and forms of abatement are phased in, and finally a carbon-free phase where only renewables are used. Subsidies on renewables bring forward the date and speed up the phasing in of renewables and will also encourage to leave more fossil fuel in situ. But as fossil fuel extraction is more aggressive in the fossil fuel only phase before it is slowed down in the phase where renewables are also phased in, a Green Paradox might occur. In the market outcome where no price is charged for carbon, full exhaustion of fossil fuel occurs and the Green Paradox raises its ugly head again.

If for political reasons coal is subsidized (or exempted from the carbon tax) as is the case in many developed economies, this will encourages substitution towards dirty coal. The big elephant in the room is thus how to reduce reliance on coal, especially as coal reserves are cheap and can last another 350 years at current usage rates. It can be shown that the “laissez-faire” decentralized market outcome starts with oil (and gas), and then switches to coal leaving oil in situ; the socially optimal outcome starts with oil, then has an oil-coal phase until oil reserves are fully depleted before switching to coal; the socially optimal outcome curbs global warming as it uses relatively clean oil to the full rather than dirty coal; and is attained with a steeply rising carbon tax during the oil-only phase and a less steeply rising carbon tax during the oil-coal phase (van der Ploeg and Withagen, 2011). Analyzing the transition from fossil fuel to clean renewables and the potential danger of falling back on dirty coal must pay attention to endogenous growth and the crucial role of directed technical change in realizing a carbon-free economy.

Technology is the key to kick-starting green innovation (Bosetti et al., 2009; Aghion et al., 2009). R&D can be directed at conventional "dirty" machines that lead to environmental degradation or to "clean" alternative machines that do not pollute. It can then be shown that, as long as the two types of machines can be easily substituted for each other, sustainable long-term growth can be attained with *temporary* taxation of dirty innovation and production but subsidies for clean R&D are needed to avoid a too high pollution tax (Acemoglu, et al., 2010). Furthermore, it pays to intervene quickly and strongly because then the slow growth transition phase lasts shorter and momentum can be built up. The policy message is the opposite of what most governments want to hear and comes over loud and clear: redirect technical change towards clean technology immediately and optimal environmental policies need not harm long-run growth prospects. Others have highlighted the role of endogenous technical progress in abatement technology and also find that whereas the level and growth and output may fall in the short run after a tightening of environmental policy, long run growth will increase (e.g., Bovenberg and Smulders, 1996). The Stern Review also argues for an immediate and aggressive response to the climate challenge, rather than a gradually rising ramp for the carbon tax, in view of the higher costs to combat global warming that this will imply in the future and the ethical case for using a very low discount rate to discount future global warming damages (Stern, 2007). And, of course, there are the well-known dangers of irreversible tipping points and catastrophic climate change that call for immediate action as precautionary preferences imply the use of a lower rate of discount.

Summing up, Sheik Yamani was right in 2001 to say that the Stone Age did not end for lack of stones and that the fossil fuel era will not end for lack of fossil fuel, but because of technology. The discussion about green growth should thus not scaremonger about running out of fossil fuel and shrinking the economy if carbon-free renewables are a realistic alternative to coal. This requires both market support engendered by a high carbon tax and R&D support in the form of a quick and sharp boost to investment in clean technology. The best is thus to avoid second-best traps and encourage R&D in clean technology via and in combination with a high carbon tax. The objective is to unhook the economy of its polluting ways and steer it to an alternative clean balanced growth path. Society is thus in need of a rapid rather than a gradual sustainability transition driven by redirecting technical change towards clean technologies.

References

Acemoglu, D., P. Aghion, L. Bursztyn and D. Hemous (2010). The environment and directed technical change, mimeo., MIT and Harvard Universtiy, Cambridge, Mass.

Aghion, P., R. Veugelers and C. Serre (2009). Cold Start for the Green Innovation Machine, Policy Contribution 2009/12, Bruegel, Brussels.

Barker, T. et al. (2007). Mitigation from a cross-sectoral perspective, chapter 11 in B. Metz et al. (eds.), Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate ChangeCambridge University Press, Cambridge, U.K.

Bosetti, V., C. Carraro, R. Duval, A. Sgobbi and M. Tavvoni (2009). The role of R&D and technology diffusion in climate change mitigation: new perspectives using the WITCH model, Department Working Paper 664, OECD, Paris.

Bovenberg, A.L. and S.A. Smulders (1996). Transitional impacts of environmental policy in an endogeneous growth model, International Economic Review, 37, 4, 861-893.

Hamilton, J.D. (2009). Understanding crude oil prices, Energy Journal, 30, 2, 179-206.

Heal, G. (1976). The relationship between price and extraction cost for a resource with a backstop, Bell Journal of Economics, 7, 371-378.

Hotelling, H. (1931). The economics of exhaustible resources, Journal of Political Economy, 39, 137-175.

McKinsey & Company (2010). Impact of the Financial Crisis on Carbon Economics – Version 2.1 of the Global Greenhouse Gas Abatement Cost Curve, McKinsey & Company,

Ploeg, F. van der and C. Withagen (2010a). Is there really a Green Paradox?, Research Paper 35, OxCarre, University of Oxford.

Ploeg, F. van der and C. Withagen (2010b). Growth and the optimal carbon tax. When to switch from exhaustible resources to renewables?, Research Paper 55, OxCarre, University of Oxford.

Ploeg, F. van der and C. Withagen (2011). Climate policy with a dirty backstop – Oil, coal, renewables and the optimal carbon tax, Research Paper 56, OxCarre, University of Oxford.

Popp, D. (2002). Induced innovation and energy prices, American Economic Review, 92, 160-180.

Sinn, H.W. (2008). Public policies against global warming – A supply-side approach, International Tax and Public Finance, 15, 4, 360-394.

Stern, N. (2007). The Economics of Climate Change: The Stern Review, Cambridge University Press, Cambridge, U.K.