## Essays in Imperfect Environmental Policies and Exhaustible Resources

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## Synopsis

There are many reasons why environmental policies are subject to imperfections. For example, the marginal benefit and cost of pollution may be unsure, so that the optimal degree of pollution is uncertain (Weitzman 1974). In this dissertation, the imperfections stem from, on the one hand, disregarded reactions of third parties to environmental policies and, on the other hand, influences of lobby groups on policies. It comprises four research papers:

- 1. 'Unilateral Climate Policy: Harmful or even Disastrous?' (with Hendrik Ritter)
- 2. 'Unilateral Supply Side Policies and the Green Paradox'
- 3. 'Lobbying over Exhaustible-Resource Extraction' (with Achim Voss)
- 4. 'Special Interest Politics: Contribution Schedules versus Nash Bargaining' (with Achim Voss)

The first and the second research papers analyze under which conditions certain environmental policies lead to the so called *green paradox*, meaning that they do more harm than good to the environment (Sinn 2008). Here, the reason for possible ineffectiveness is the reaction of indirectly affected players, i.e. exhaustible resource owners, to a unilateral policy. Essay three investigates how a welfare-maximizing extraction path is altered due to lobbying by exhaustible resource owners. Here, the reason for inefficiency is the influence of directly affected players on the policy. The forth research paper is a technical extension of the third. It demonstrates that the policy with lobbing is the same in the contribution-schedules equilibrium as in the Nash bargaining solution whereas payments and utilities differ.

The commonalities between essay one, two and three are that they deal with imperfect environmental policies and include exhaustible resource owners facing marginal extraction costs which are increasing in current and cumulative supplies. All four research papers use microeconomic theory to analyze the behavior of the involved agents in response to certain policies. While essay one and two apply general equilibrium models with two periods and three players, the models in essay three and four are partial equilibrium, the former with n periods and two players, the latter with one period and n players. The policy instrument in the first research paper is to tighten an emissions cap, in the second to purchase (and preserve) additional deposits, and in the third to set extraction quantities or, equivalently, extraction taxes. In the forth research paper, there is a continuum of unspecified policies.

Essay one and two investigate under which conditions certain environmental policies lead to an increase in early emissions, the so called *weak green paradox*, and to an increase in total emissions damages, the so called *strong green paradox* (Gerlagh 2011). The latter occurs, e.g., if early and total emissions increase or if early (total) emissions increase and total (early) emissions stay constant. Both research papers consider demand side (unconstrained fossil fuel consumer) and supply side (fossil fuel extractor) reactions to unilateral environmental policies. They consider relative price effects by applying general equilibrium models and endogenize cumulative extractions by assuming stock-dependent marginal extraction costs. With this kind of model, an increase in total emissions due to unilateral environmental policies is possible.

Our model is based on Eichner & Pethig's (2011) model without extraction costs. As far as I know, only essay one and two, van der Meijden et al. (2015) and van der Ploeg (2016) use general equilibrium models with stock-dependent marginal extraction costs in the green paradox literature. However, essay two is the only one from these research papers that considers carbon supply reducing policies (cf. Harstad 2012, Hoel 2014).

The main results of essay one are as follows: If the abating country tightens its emissions cap in the first of the two periods, present emissions in the non-abating country increase because the present fossil fuel price declines relative to the present commodity price (*carbon leakage*). Total emissions in the first period increase if the intertemporal elasticity of substitution in consumption is low and the user cost of extraction is high (*weak green paradox*). Depending on the price elasticities of demand and supply for fossil fuel, an increase in present emissions can coincide with an increase in cumulative emissions (*strong green paradox*). If the emissions cap is tightened in the second period, the green paradoxes occur under somewhat opposite conditions. However, cumulative emissions in the non-abating country can also decline (*negative cumulative carbon leakage*).

In essay two, I demonstrate that the qualitative results concerning the green paradoxes are quite similar when the policy instrument is changed from tightening an emissions cap to purchasing (and preserving) additional deposits. Moreover, I derive conditions under which it is more effective first to purchase the lowest-cost deposits and then to purchase additional high-cost deposits, something that has not been derived in the literature so far.

Essay three investigates how extraction and contribution payments develop over time if there is lobbying by exhaustible resource owners. The government has a mixed motivation of intertemporal welfare-maximization and contribution payments (Grossman & Helpman 1994). We apply a Nash bargaining model, so that both agents benefit from the cooperative solution. How much they benefit depends on their exogenous bargaining powers and endogenous disagreement utilities. The agents negotiate in each period and assume that they cooperate forever. However, the noncooperative solution is important for the disagreement utilities. Here we assume that if negotiations fail once, the agents leave the bargaining table forever (Petrosyan 1997). Then, the lobby group pays nothing and the government maximizes intertemporal welfare.

Our model combines lobbying in the tradition of Grossman & Helpman (1994), dynamic (Nash) bargaining and (exhaustible) resource extraction with stock-dependent costs as well as stock-pollution damages. Similar models in the literature are those from Barbier et al. (2005), Boyce (2010) and Andrés-Domenech et al. (2015). Different to these models, we include monopoly rents and flow-pollution damages in our analysis.

The main results are as follows: In the cooperative solution, extraction is a compromise between welfare- and profit-maximization. How strong the influence of the lobby group on the policy is does not depend on the bargaining powers but on the relative valuation of the contribution payments: The more the government cares for contribution payments and the less the lobby group must spend to collect them, the stronger is the influence of the lobby group. The development of contribution payments reflects the conflict of interest between the agents: If the preferred extraction quantities differ widely, contribution payments are high, and vice versa. In the long run, when marginal extraction costs become prohibitively high, the preferred extraction quantities of both agents become zero, so that the conflict of interest and thus the contribution payments vanish. Because of stock-pollution damages, the preferred cumulative extraction quantity of the government is reached before extraction stops. When it is reached, contribution payments jump up because the disagreement utility of the exhaustible resource owners deteriorates, so that their willingness to pay increases sharply.

In what follows, the abstracts, co-authorships, conference presentations and scientific disseminations of the four research papers are presented in tabular form.

Publication Ritter, Hendrik & Mark Schopf (2014), 'Unilateral Climate Policy: Harmful or even Disastrous?', Environmental and Resource Economics 58(1), 155–178.

Abstract This paper deals with possible foreign reactions to unilateral carbon demand reducing policies. It differentiates between demand side and supply side reactions as well as between intra- and intertemporal shifts in greenhouse gas emissions. In our model, we integrate a stock-dependent marginal physical cost of extracting fossil fuels into Eichner & Pethig's (2011) general equilibrium carbon leakage model. The results are as follows: Under similar but somewhat tighter conditions than those derived by Eichner & Pethig (2011), a *weak green paradox* arises. Furthermore, a strong green paradox can arise in our model under supplementary constraints. That means a "green" policy measure might not only lead to a harmful acceleration of fossil fuel extraction but to an increase in the cumulative climate damages at the same time. In some of these cases there is even a cumulative extraction expansion, which we consider disastrous. Co-authorship Research idea and introduction mainly by Hendrik Ritter. Model jointly developed by Hendrik Ritter and Mark Schopf. Calculations, body and conclusion mainly by Mark Schopf.

Conference Mannheim Energy Conference, Mannheim, June 2012.

Presentations Annual Conference of the European Association of Environmental and Resource Economists, Prague, June 2012.

> Annual Congress of the International Institute of Public Finance, Dresden, August 2012.

Scientific The work on this paper started in June 2011 and reached the status Dissemination of a working paper in May 2012 under the title 'Reassessing the Green Paradox'. It was submitted to *Environmental and Resource Economics* in May 2012 and revised and resubmitted in March 2013 and June 2013. It was accepted for publication in June 2013, published ahead of print in July 2013 and published in print in May 2014. Publication Mark Schopf (2016), 'Unilateral Supply Side Policies and the Green Paradox', UPB Dissertation Working Paper No. 28.

Abstract This paper deals with possible foreign reactions to unilateral carbon supply reducing policies. It differentiates between demand and supply side reactions as well as between intra- and intertemporal shifts of greenhouse gas emissions. Ritter & Schopf (2014) integrate stock-dependent marginal physical extraction costs into Eichner & Pethig's (2011) general equilibrium carbon leakage model. Using this model, we change the policy instrument from an emissions trading scheme to a deposit preserving system. The results are as follows: Under similar conditions than those derived by Ritter & Schopf (2014), the weak green paradox and the strong green paradox arise. In case of acting today, these conditions are tightened due to the energy market channel of carbon leakage. In case of acting tomorrow, the change in the physical user cost of extraction additionally influences the effectiveness of the carbon supply reducing policies. In both cases, it can be more effective to preserve the deposits with the lowest marginal physical extraction costs first. Conference International Energy Workshop, Paris, June 2013. Presentations International Association of Energy Economists European Conference,

Düsseldorf, August 2013. European Economic Association Annual Congress, Gothenburg, August

2013. Scientific The work on this paper started in January 2013 and reached the status Dissemination of a working paper in June 2013 under the title 'Preserving Eastern or Offshore Oil for Preventing Green Paradoxes?'. It was thoroughly revised from January 2016 to April 2016.

Publication	Voss, Achim & Mark Schopf (2016), 'Lobbying over Exhaustible-Resource
	Extraction', UPB Dissertation Working Paper No. 26.

Abstract	Consider a lobby group of exhaustible-resource suppliers, which bargains
	with the government over the extraction of an exhaustible resource and
	over contribution payments. We characterize the equilibrium extraction
	path and the development of contribution payments in time. The lat-
	ter relates to the development of the conflict of interest between profit-
	maximization and welfare-maximization. Due to stock pollution dam-
	ages, the government prefers a lower level of cumulative extraction than
	the lobby group in the long run. In the meantime, the resource suppliers'
	aim to maximize profits implies that equilibrium extraction may be too
	slow to maximize welfare, while flow-pollution damages imply that it may
	be too fast.

Co-authorship	Research idea and model jointly developed by Achim Voss and Mark
	Schopf.
	Calculations and writing in equal parts by Achim Voss and Mark Schopf.
Conference	Nachwuchsworkshop Umwelt- und Ressourcenökonomie, Kiel, February
Presentations	2014.

Conference on Sustainable Resource Use and Economic Dynamics, Ascona, June 2014.

World Congress of Environmental and Resource Economists, Istanbul, June 2014.

Jahrestagung des Vereins für Socialpolitik, Münster, September 2015.Research Seminar on Environmental, Resource and Climate Economics, Berlin, November 2015.

Scientific The work on this paper started in July 2013. A previous version was Dissemination published in January 2014 as part of the dissertation 'Essays in Environmental Policy and Political Economy' from Achim Voss. It was submitted to the *International Economic Review* in June 2015 and is currently under revise and resubmit.

Publication	Voss, Achim & Mark Schopf (2016), 'Special Interest Politics: Contribu-
	tion Schedules versus Nash Bargaining', UPB Dissertation Working Paper
	No. 27.
Abstract	The article compares two models of lobby influence on policy choice: The
	Grossman & Helpman (1994) contribution-schedule model and a negoti-
	ation between the lobbies and the government summarized by a Nash-
	bargaining function. The literature uses the models interchangeably be-
	cause they imply the same equilibrium policy. We derive under which
	conditions they lead to the same payments, equilibrium utilities, and total
	efficiency. They coincide under particular assumptions about bargaining
	power and disagreement utility.
Co-authorship	Research idea and model jointly developed by Achim Voss and Mark
	Schopf.
	Calculations and writing in equal parts by Achim Voss and Mark Schopf.
Scientific	The work on this paper started in December 2015 and reached the status
Dissemination	of a working paper in February 2016. It was submitted to the $Journal of$
	International Economics in March 2016 and is currently under review.

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