

Presentation Outline
Is There a Green Paradox, and if so, How do we
Respond?

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Abstract

In this expose, we explain Sinn's Green Paradox, according to which unilateral policies to reduce demand, will be ineffective to stop global warming, as foregone consumption and welfare is merely redistributed to other consumers, given the price inelasticity of fossil fuel supply. Moreover, fossil fuel owners anticipate likely future demand reductions, and react by extracting early.

The Green Paradox is presented in some detail, criticized and questioned on the merits of its assumptions. Both the assumed dynamic under the green paradox, traditional green policy paradigms and the choice *of* a global greenhouse gas reduction regime are modeled as games. It is suggested that unless global green policy is accompanied by ex-post redistribution between developed and undeveloped, fossil fuel importing and exporting countries, individually rational actors will not achieve the social optimum. Questions and directions for further research are provided.

Contents

1	Introduction	
	Global Warming — The Policy Challenge of Our Time	4
2	Traditional Green Policies — Drops in the Bucket	5
2.1	German Green Policy	5
2.2	A European Emissions Trading Systems	6
2.3	Convictions of Traditional Green Policies	6
3	The Green Paradox — Sinn's Critique	6
3.1	Subsidies are Inefficient, Inconsistent	7
3.2	Unilateral Action is Ineffective — The Green Paradox, Part I	7
3.3	Increasingly Tightening Demand May Make Matters Worse — The Green Paradox, Part II	9
3.4	Sinn's Way Out — Policy Proposals, Part I	10
4	Critique of Sinn: Is there a Green Paradox?	14
4.1	Conceptual Assumptions	14
4.2	Empirical Assumptions	15
4.3	Which Fossil Fuels?	16
4.4	The Merit of Sinn's Proposals	17

5	Game Theoretic Modeling	18
5.1	The Game of the Green Paradox	18
5.1.1	... Given Traditional, Unilateral Green Policy	18
5.1.2	... Given That Saving Helps	19
5.1.3	Rationality and Time Horizons	20
5.1.4	The Sequential Game of Overextraction	21
5.2	The Games of Choosing a Emission Regime	21
5.2.1	The “Copenhagen” Game	21
5.3	Conclusion: Should We Believe Sinn?	24
6	Policy Proposal	25
6.1	Lowering Capital Interest Rates for Fossil Fuel Money	25
6.1.1	“Copenhagen” Game vs. Source-Based Capital Gains Tax on Fossil Fuel Money	25
6.1.2	Alternative Taxes and Inflation	25
6.2	Redistribution	26
6.2.1	“Copenhagen” Game with Ex-Post Redistribution	26
6.2.2	How Could This Work in Practice?	26
6.2.3	Is This Fair? And What About Per-Capita Emission Rights?	26

Climate change (...) is the greatest and widest-ranging market failure ever seen.

The Stern (2006) Review: The Economics of Climate Change

Note to the Reader: Skip Ahead In the below, we first reproduce Sinn’s critique vis-à-vis traditional green policies and theorizing. For our critique, application of game theory and policy proposals, please skip ahead to section 4.

1 Introduction

Global Warming — The Policy Challenge of Our Time

Anthropogenic global warming has now been an established scientific fact beyond reasonable doubt for some time. Human-made CO₂e¹ emissions as well as changing land use (e.g. deforestation) are changing the climate of our planet.

The use of the planet’s fossil fuels — oil, coal and gas — play an important role in this process. Economic incentives under the status quo do not take account of the environmental damage sustained by excessive burning of fossil carbon. Policy makers need to “price in” the negative greenhouse externality into the market. Adding to the stock of CO₂ in the atmosphere must become more expensive relative to other economic activities. The Intergovernmental Panel on Climate Change (IPCC) and the UK-government sponsored Stern Review (2006) have established 2 degrees of average warming or 400ppm CO₂e as maximum levels of accepted global warming, beyond which the a runaway global warming of non-linear, “tipping-point” (Gladwell, 2001) dynamic is likely, the costs of which in capital and human suffering will be tremendous.

On the other hand, current economic development greatly depends on the easy availability of fossil fuels². Fossil fuels have no close substitutes:

¹CO₂e stands for CO₂ equivalents, a unit transforming all relevant greenhouse gases into CO₂, taking account of their differential effect and resorption. While the discussion here, as elsewhere, focuses in CO₂, Methane and water vapor emissions are in fact also important contributors to global warming.

²Sinn (2008a) even seems to suggest that the discovery of oil itself brought about economic modernity, saving humanity, as he says, from a Malthusian world of geometric

their energy densities are met by no other technology or material widely available at this time, making them particularly suitable for mobile applications and transportation. Fossil fuels are also essential raw materials for petrochemistry, with products ranging from pharmaceuticals to synthetic materials.

Fossil fuels are valuable in the long run, and harmful when burned at a high rate today. At the same time, cutting down on fossil fuel consumption will reduce the welfare of present generations, and enhance that of future generations. Global warming policy is then not only must internalize the climatic costs of CO₂*e* emissions, but it must also balance welfare intertemporally.

In the below, we outline the “traditional” policy responses to this end.

2 Traditional Green Policies — Drops in the Bucket

Traditional green policies have aimed to reduce fossil fuel consumption, both by making it more expensive and by subsidizing the development and provision of substitutes.

2.1 German Green Policy

Germany is a good example, featuring a host of green policies.

On the one hand, it features a set of pigouvian taxes, most notably the Ecotax (“Ökosteuer”) and the Energy Tax (“Energiesteuer”, before 2006 Mineralölsteuer). Both are *unit* taxes on *energy* consumption, or increasing entropy. Tax rates differ between energy sources and also include energy from renewable sources. Because these taxes are based on energy, their effective rates only imperfectly internalize the costs of CO₂*e* emissions. Additionally, a wide range of sources and uses (e.g. air travel, agriculture) are exempted from these taxes or charged lower rates, distorting marginal costs for CO₂*e* reductions between the tax-exempted uses and other sectors. Both taxes also feature provisions for non-global warming related environmental concerns, such as the phasing-out of sulfur fuels.

On the other hand, german green policy has included legislation subsidizing measures to enhance efficiency (e.g. insulation) and develop or provide substitute, alternative sources of renewable energy. The latter have included both direct subsidies into research as well as mandated feed-in tariffs for renewables from utilities.

population growth, and linearly constrained resource.

2.2 A European Emissions Trading Systems

At the forefront of global climate policy, and in addition to the above-mentioned policies the European Union has instituted the first ever international emissions trading system (EU-ETS) on January 1, 2005. It covers large polluters, to whom emission rights are allocated (later auctioning is planned), who can then trade rights with one another, creating an EU-wide price for CO₂*e* emissions, based on the allocated total permissions.

The idea of Emissions Trading Systems is to internalize the price of CO₂*e* emissions by creating a universal price for marginal CO₂*e* reductions, incentivizing the cheapest reduction over all uses.

2.3 Convictions of Traditional Green Policies

Three central convictions underly traditional green policies:

Subsidies Help Particularly in the German context, traditional green policy has included the subsidizing of selected future technologies to enhance efficiency and develop substitutes to fossil fuel (e.g. hydrogen, wind power). In lieu of a mere internalizing of externalities, based on which new technologies and changed behavior would arise, policy makers have taken a more directive approach, trying to pick the winner.

Unilateral Action Helps The EU, and Germany in particular, pride themselves for being on the forefront of green policy. While the inaction of other countries is deplored, it is argued that the EU serves as a rolemodel and that even given other's defection, unilateral emission reduction helps reduce global warming.

Reducing Demand Helps At a fundamental level, EU and German policies — from Ecotax to EU-ETS — are tackling the demand side of CO₂*e* emissions. The supply side, namely the owners of fossil fuels, do not prominently feature in policy making.

3 The Green Paradox — Sinn's Critique

Sinn (2008*b*; 2007; 2008*a*; 2009) takes issue with all of the above convictions of traditional green policy. He maintains that there is a Green Paradox of unilateral decreases in carbon demand, dynamics elsewhere described also as leakage and rebound effects (Fölster and Nyström, 2009).

3.1 Subsidies are Inefficient, Inconsistent

As a sidekick to his main argument of a green paradox, Sinn heavily criticizes the interventionist stance behind much of green policy subsidizing. He argues that these policies are inefficient because of the arbitrary distortions they impose on an otherwise universal marginal price for CO₂*e* emissions (e.g. by differential ecotaxes based on energy source), and the uncertain success of the respective technologies (solar power).

He also points out that the present subsidizing of renewable energies in Germany is inconsistent with the EU-ETS, which does not account for the emissions saved by means of this intervention. He points out, that in fact, a renewable energy subsidy under EU-ETS will serve merely to redistribute wealth from Germany to its European neighbours.

3.2 Unilateral Action is Ineffective — The Green Paradox, Part I

Based on a model of relatively more elastic demand than supply of fossil fuel, Sinn argues that unilateral reductions of demand by a subset of buyers will not reduce aggregate consumption, but merely redistribute consumption and wealth from the savers to the rest. He maintains that because resource owners dispose of a fixed stock of fuel, they do not produce price-elastically, like normal producers, but extract price-inelastically (more below).

The argument proceeds as follows. When a group of countries, by some mean of traditional green policy increases the relative price of fossil fuel energy generation (EU-ETS, Ecotax, Subsidies) vis-à-vis other economic activities or sources of energy, the price elastic demand for fossil fuel will decrease. That lowered price, however will cause the rest of the world to increase their consumption.

This effect is modeled in Figure 1. The (light grey) demand curve of “green” countries is shifted downward by the abovementioned demand-reducing policies. The world market price drops from P^* to P^{**} . It is then conventionally assumed that amounts will drop likewise. Given a relatively price-inelastic supply side, however, producers will maintain their production at previous levels and the excess amounts will be bought at a cheaper price by the rest of the world.

This effect then renders the international political economy of reducing CO₂*e* emissions a zero-sum game — when reduction efforts are not undertaken by everyone.

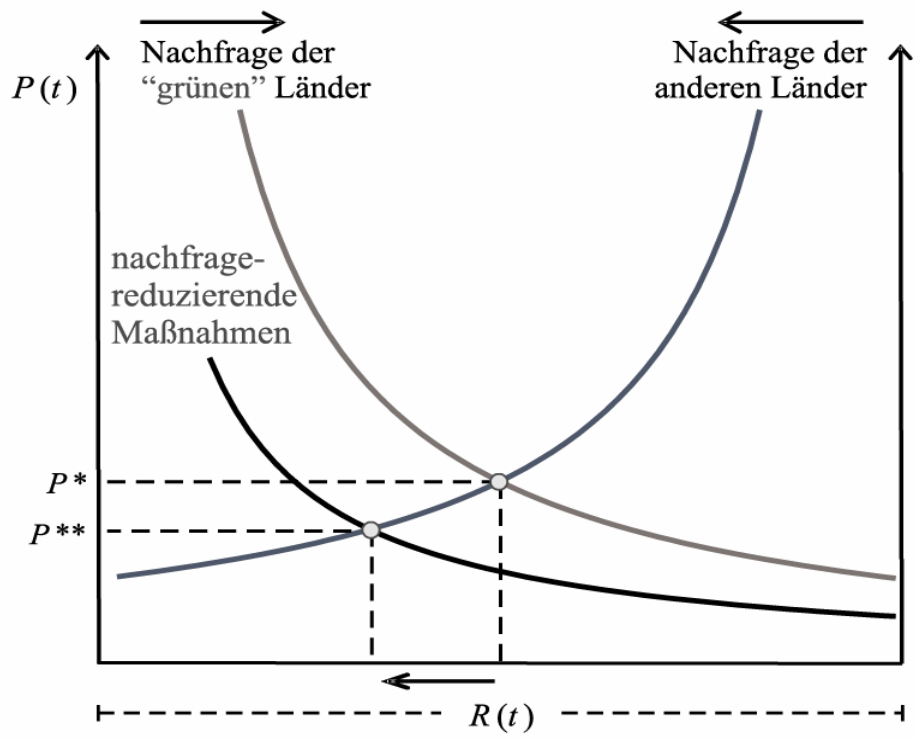


Figure 1: Zero-Sum Redistribution of CO2 Emissions Under Unilateral Reduction, (Sinn 2008b: 11)

3.3 Increasingly Tightening Demand May Make Matters Worse

The Green Paradox, Part II

The second turn of Sinn's suggested Green Paradox assumes that given the fixed stock of fuel resource owners dispose of, they react to price signals only by changing the course of their extraction, not the total amount over all periods³. Resource owners then care only *when* to extract, not how much.

The Intertemporal Portfolio Optimization of Resource Owners

Their decision is an intertemporal portfolio optimization. At any given point, they balance the expected future prices of their resources — the fossil fuel interest — with the interest they could generate investing the current-price revenue of a marginal unit of fossil fuel on the capital markets.

A couple of more complications apply. Resource owners will subtract from the pure fossil fuel interest the risk of expropriation that they expect in the course of potential political reform or turmoil. The costs of extraction are not included here, because they accrue both at present and future extraction.

The equilibrium condition for the intertemporal portfolio optimization of resource owners is then:

$$i_{Capital} = i_{Fuel} - p_{Expropriation} \quad (1)$$

Sinn notes that this condition is neutral to the selling (not extraction) of fossil resources. The above intertemporal portfolio decision would then be made by the new owner according to the same equilibrium condition 1.

Resource owners thereby act interest elastic in their supply, but not price elastic: only the expected first derivative of prices matters.

Green Policies and Extraction Paths — The Greener it Gets, the Worse

The Green Paradox, Part II then arises from the future fossil fuel prices that resource owners expect as a function of green policy. The very expectation of increasingly demand — and thereby price-depressing green policy will then prompt resource owners to extract more today, and less later. If resource owners extract faster, more CO_{2e} will enter the atmosphere earlier, further increasing the flow of greenhouse gases.

It is important to note that what matters for the greenhouse effect is of course not the flow of CO_{2e}, but its stock in the atmosphere in parts per

³This holds true so long as extraction costs are not higher than prices, which currently seems unlikely to happen in the near future.

million (ppm). Because the planet’s ecological system does in fact include a resorption mechanism (increasing biomass, deep ocean water), which can, albeit at a very low rate, reduce the stock of emissions, an extraction path needs to be as flat as possible to maintain *net* stock increases as low as possible. Emitting at a slower rate, and later, matters. This can be expressed as follows:

$$Atmosphere \uparrow \Rightarrow Temperature_{World} \uparrow \quad (2)$$

$$\Delta(t, t + 1)Atmosphere = Atmosphere_t + \sum_{i=1}^{t+1} Emissions_i - \sum_{i=1}^{t+1} Resorption_i \quad (3)$$

Green policy depresses future price expectations of resource owners in three ways. Firstly and most straightforwardly, much of it is implemented with increases grandfathered-in, such as by incremental tax increases or decreasing total of emission rights. Secondly, green policy legislation as such tends to proceed from less demand-reducing to more demand-reducing, both because future prices of such reductions are expected to be cheaper, and for political reason. Thirdly, present (subsidized) investment in substitute technologies will likely dramatically reduce the cost and widen the availability of these alternative sources of energy, further depressing future demand and prices for fossil fuels.

3.4 Sinn’s Way Out — Policy Proposals, Part I

Sinn provides suggestions how to resolve the different aspects of the policy dilemma.

Boundary Condition: Increase CO2e Resorption Sinn points out, that the only genuine — if exogenous to his modeling — solution to positive, and increasing net CO2e changes are reforestation and carbon capture and storage (CCS)⁴. CCS, Sinn finds to be a promising technology albeit with uncertain success. Reforestation remains as an effective policy to fight global warming. A systematic investigation of the capacities and costs of massive reforestation, for which Sinn provides only anecdotal statistics, is unfortunately beyond the scope of this essay.

⁴There are in fact more than just these two possibilities to increase the earth’s CO2 uptake, such as increasing oceanic resorption.

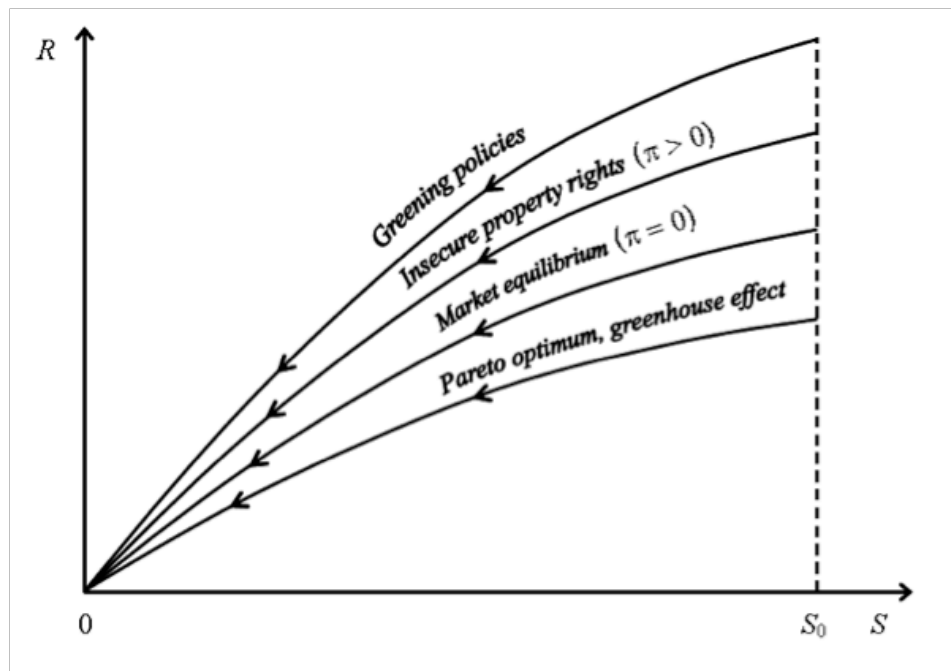


Figure 2: Different Extraction Paths, (Sinn 2008b: 11)

A Global Demand Cartel As evident from the above modeling, unilateral green policies crucially fail because given constant supply, suppressed prices are exploited by additional consumption of other players. A global demand cartel, or multilateral, universally binding demand-reducing regime can overcome this problem. In principal, this is possible both by means of a universally binding ETS (“Super-Kyoto”) or a universally binding tax regime (“global ecotax”). Given a demand cartel, sellers will find no buyers for their surplus quantities, irrespective of the price.

The Costs of a Global Demand Cartel Sinn points out that aside from effectively fighting over-extraction of fossil carbon, thereby improving on the social optimum, a global demand cartel also has massive redistributive effects. A global ETS will effectively expropriate resource owners of that price difference caused by its demand-reducing policies — over all periods. That amount is redistributed to net fuel importers as emission right auctioning revenue, or without auctioning, to those firms in net fuel importing countries who manage to cut emissions and sell respective rights.

The Dangers of a Global Demand Cartel Sinn is deeply skeptical about the dangers of the powerful institution that a global demand cartel would create. He fears that in the absence of effective global democratic controls, such UN-level institution would be wrought by massive, zero-sum interest conflicts, likely creating discretionary and highly distortionary exemptions or privileges for some countries, sectors or activities. He also points out that an international agreement on such a demand cartel, given the great redistributive dynamics both within net-fuel importers, and even more between net-fuel importers and net-fuel exporters, is unlikely to arise in the first place⁵.

Changing the Intertemporal Portfolio Optimization Parameters

Sinn provides a number of innovative solutions to change the parameters of the intertemporal portfolio optimization undertaken by resource owners. Recall that the relative interest rates of the capital market, and fossil fuels in the ground matters for the chosen extraction path of resource owners. Sinn points to possibilities to change these relative interest rates.

⁵For greater simplicity, we speak here of net-fuel importers compared to net-fuel exporters. In truth, the picture is a little more difficult: what matters is the net result of changes in welfare from prevented climate change and the change in revenue streams from resource extraction.

Soothe Fears of Expropriations — *a.k.a.* Save the Despots

One powerful, if uneasy conclusion that arises from Sinn's arguing is that political stability in fuel-exporting regimes is beneficial for the climate, irrespective of otherwise desirable democratic reform of these often undemocratic regimes. He argues that any transition away from current regimes is likely to include expropriations of current resource owners. Given the gross inequalities in many of these countries and the fierce rivalry between competing elites, this seems in fact likely. The very expectation of this probable expropriation then will cause frontloaded extraction paths — to the detriment of the environment.

Tax Oil Money Two possible parameters in equation 1 remain: the fossil fuel interest and the capital market interest. The suggestion for a source-based capital gains tax by net-fuel importers vis-à-vis net-fuel exporters changes the latter. By reducing the post-tax interest rate of a great share of (effectively, OECD) capital markets, this source-based capital gains tax will serve to make fossil fuel *in the ground* relatively more attractive. If sheiks cannot get a good interest rate in the market, they may as well leave more fossil fuel in the ground, for later extraction at higher prices.

Two important notes apply here. First, given global capital mobility, said source-based capital gains tax will work only if there is a near-perfect degree of international, or at least OECD-wide harmonization of tax rates. No tax competition with lower rates, hoping to attract more capital must happen.

Secondly, Sinn points out that a source-based capital gains tax will have only a limited, dampening effect on extraction paths. It will necessarily leave the capital market interest rate for resource owners at or, in the most extreme case, slightly below zero (inflation). As such, a negative interest rate on fossil fuel, either through fear of expropriation or an expectation of further reductions in demands cannot be completely counteracted.

Frontloaded Green Policy It has been argued before that grandfathered green policy can be greatly detrimental, by steepening the extraction path. The opposite solution, a frontloaded green policy, imposing the greater burden of saving CO₂e today, and a smaller burden in the future would do the opposite. When implemented credibly, it would cause resource owners to expect less depressed prices in the future, causing them to postpone some extraction.

This policy proposal, as Sinn admits, will likely remain in the abstract,

for a frontloaded green policy is not politically feasible. In addition to Sinn's critique, one must add that as-of-yet unavailable green technology would also make a frontloaded green policy excessively expensive, for it is likely the marginal costs of CO₂e reductions will fall in the future.

4 Critique of Sinn: Is there a Green Paradox?

Sinn's hypothesis of a green paradox must be criticized on the merit of its assumptions.

4.1 Conceptual Assumptions

Complete Rationality This is of course a generic critique of economic modeling — the validity of Sinn's hypothesizing rests on the assumption of completely rational behavior of the respective actors. Generic, but key in this case, are questions whether resource owners really rationalize their extraction paths with such a long time-horizon that lies way beyond their own, or even their offsprings lifetimes. It appears likely, that in fact, boundedly rational or irrational actors would rather be led by more short-term, or less quantifiable "reasons".

Optimizing Under Uncertainty Sinn assumes a relatively small degree of uncertainty over the very distant future, in his modeling of the intertemporal portfolio composition problem of resource owners: it is assumed that, even when fully rational, actors can meaningfully rationalize over the very distant future, that sufficient amount of reliable data, or at least (normally distributed) probabilities are available. This alone seems questionable.

More dramatically, Sinn assumes that the degree of uncertainty over payoffs is same between the two "investments", capital and fossil fuel in the ground. If anything, by pointing to the danger of expropriation, he assumes that fossil fuel will be the more uncertain resource. This seems doubtful on a number of accounts. First of all, it is not entirely clear, why only material resources would be subjected to said expropriation, and not equivalently, the Swiss bank account, too.

Given the 2007-2009 financial crisis, one may in fact assume that in fact, financial markets are much more prone to extremely improbable, but high impact events, so called "Black Swans" Taleb (2007) far outside the normal distribution. A resource such as fossil fuel, that for the foreseeable future seems irreplaceable in petrochemistry, but also only imperfectly

substitutable as a source of energy may be assumed to carry much less uncertainty.

4.2 Empirical Assumptions

Price Expectations of Fossil Fuels At the heart of Sinn’s green paradox, part II, lies the notion that green policies will be able to effectively suppress fossil fuel prices. It is key here to note, that Sinn’s modeling requires fossil fuel prices to fall *in the absolute*, not just *relative* to an assumed business-as-usual-scenario. This, given high growth rates, particularly in fossil-fuel hungry developing markets (China, India), who, for future growth appear to depend on more fossil fuel, seems doubtful. Potentially — if detrimental for the environment, too — future growth will create such insatiable demand for fossil fuels that prices will continue to increase, or stay constant, even in the presence of demand-depressing green policies, be it unilateral or multilateral.

Price (In)elasticity of Supply The former point has ramifications for the central assumptions of the price inelastic supply of fossil fuel which in turn is responsible for Sinn’s green paradox, part I. If, as argued in the above point, resource owners can expect same or even further increasing prices of oil in the future because of its scarcity and insatiable demand, they may have reason to act price elastic in the presence. If they expect to see demand growth in the future that exceeds the impact of demand-depressing green policies, they will curtail production in the present period, if they see prices fall.

This would then invalidate Sinn’s fear that unilateral CO₂e saving will only cause other players to buy more carbon at a cheaper price. That cheaper price would then not exist, because, anticipating higher returns in the future, resource owners would cut extraction.

Or Does It? — In Supply, Less Is Better We suspect that the above argument does, in fact, not completely negate the dynamics feared by Sinn. While it may be true that demand will continue to grow, and with it, prices, it appears possible that prices could be higher *still*, if it were not for anticipated reductions in demand caused by grandfathered green policies. The implied counterfactual is key, here: while demand and prices will indeed rise, they could rise even more without green policies.

This is easily visible in equation 1: what matters for the intertemporal portfolio optimization of resource owners is not just the *sign* of the interest

rate of fossil fuel *in situ*, i_{Fuel} , but how large it is. For the purposes of abating climate change by means of a flattened, stretched-out extraction path, this interest rate can hardly be high enough, and any dynamic that suppresses it, if only marginally, must be considered counterproductive.

Fuel Price Fluctuations — A Case for *Interest*, not Price Elasticity Critics of Sinn quickly point to the colossal fluctuations in crude oil prices, most recently during the course of the 2007-2009 financial crisis, and take that as evidence of price elasticity. We think this interpretation is also flawed. Going back to equation 1, the observed price fluctuations could also be due to *expectations* of rising prices after the crisis, increasing i_{Fuel} during its onslaught. Looked at this way, past fluctuations could also be interpreted as empirical support of *interest*-, not price-elastic supply.

Inelastic Extraction Capacity When modeling frontloaded extraction out of fear of future green policies, Sinn assumes that resource owners are able to substantially expand their extraction capacity in the near and medium future. This may also be called into question, given currently limited extraction capacities and little investment in future capacities.

Or Does It? — Later Peak Oil is Better Similar to the above rejection of optimism concerning price elasticity, criticizing Sinn by pointing to limited extraction capacities (“Peak Oil” is reached) largely misses his point. Shifting the burden of the proof again, the question is not whether extraction *cannot accelerate*, but whether *it could decelerate faster* if front-loading were not individually rational for resource owners.

4.3 Which Fossil Fuels?

Further questions arise to which, if any fossil fuels, Sinn’s modeling may apply.

Gas is unlikely to be an applicable market, because resources are still plentiful, requiring extremely far-sighted rationalizations for the green paradox to arise. Moreover, there is no global market for gas, for it cannot be transported easily.

Coal is even more unlikely to be subjected to a green paradox. Coal resources, particularly in the US, China and South Africa seem plentiful for the meaningfully foreseeable future.

4.4 The Merit of Sinn's Proposals

The Bashing of Renewables, Efficiency Subsidizing Sinn figuratively takes German green policy out on a tour. While his criticism of lack of EU-Integration, redundant complexity and discretionary exemptions is well-founded, we disagree with him where he fundamentally rejects the subsidizing of new technology in renewables and efficiency enhancements. Circularly true of course, given his assumptions of a perfect market with infinite foresight and rationality, said investments would be undertaken by individuals given the right expected or present carbon price. We believe such uncritical belief in the market to be misleading.

First of all, said assumptions of infinite foresight and rationality are unlikely to be met by real life investors. It seems doubtful that investors will be willing to invest in technologies that may not be profitable for decades to come.

Secondly, and more endogenous to traditional economic modeling (while foreign to that of Sinn) an *Infant Industry* argument of sorts may apply to new technologies in renewables and efficiency enhancement. To become competitive, these innovations may well first have to be prototyped, improved and scaled up in protected corners of the market before they can prove their superiority on the market. The phenomenal technological progress of wind power in Germany seems to support this view of things.

Additionally, an infant industry incubation seems all the more important, given that we may find ourselves urgently needing substitute technologies, once a global ETS is implemented. To then wait for normal development cycles may be unacceptable.

On Front-loaded Green Policy As Sinn rightly points out himself front-loaded green policy is unrealistic, politically — even if it would serve to postpone fossil fuel extraction by rational owners. In addition to a political calculation, we also think an excessively front-loaded green policy may be welfare-depressing, when emissions have to be curbed at a time when substitute technologies are not yet cheaply and widely available.

On the Dangers of a Global ETS Regime Sinn is emphatic in his fear of an overly powerful, unaccountable, potentially inefficient, and likely corruptive global ETS institution. We believe his fears to be fruitful grounds for careful institutional design of an ETS regime, but do not accept it as an argument against it.

Sinn’s alternative suggestion of a source-based capital gains tax on fossil fuel-rich countries, incidentally, would require an equally, if not more powerful institution, organizing completely uniform tax rates across, at least all transition and developed economies, something that has never effectively happened at any international level before. To be successful, that institution would itself have to be very powerful, assuming, in part, the responsibility to tax, one traditionally reserved for nation states.

From this emerges a greater insight: to solve the cooperation problem that climate change is, there may *be* no alternative to delegating some responsibility to a higher level, with hopefully adequate accountability. The absence of a collectively rational actor is of course the very defining problem of this, as any Tragedy of the Commons (Hardin, 1968).

5 Game Theoretic Modeling

In the spirit of our course on “Strategy, Organization and Regulation” by Professor Hans Grüner, we here enlist game theory to make sense of the models presented so far. We agree with Sinn in the sense that we assume climate protection to be a problem of imperfectly coordinated, but intricately interdependent actors and actions. Building on a game theoretic modeling, we suggest a set of different institutions that may serve climate protection better than the status quo, or a potential Green Paradox.

We look at games at multiple levels: games *given* specific regimes of CO_{2e} emissions, and the very games of *choosing* such an arrangement.

5.1 The Game of the Green Paradox

5.1.1 ... Given Traditional, Unilateral Green Policy

Payoff matrix 1 illustrates the game of the green paradox, as assumed by Sinn, given traditional, unilateral green policy. For the sake of more intuitive understanding, this game is modeled using ETS or no ETS as decision options, and the EU and Rest of the World (ROW) as the other players. A more generic version with any kind of demand-reducing policy, and respective savers versus the Rest of the World will not differ.

Players are awarded both 3 units, if they both adopt an ETS, effectively depressing demand everywhere and decreasing CO_{2e} emissions. If one of them chooses not to adopt an ETS, all benefits to climate change disappear, as Sinn assumes, and payoffs are merely redistributive, by which whoever

implements an ETS, pays the other player 5 units. Similarly, if both players choose not to implement an ETS, the collective payoff is 0, with no redistribution. This is the pre-Kyoto status quo.

In this game, the strictly dominant strategy for both players is, *not* to adopt an ETS. The Nash equilibrium is then no ETS by either player.

Contrast this with a universal ETS payoff of 6 units, collectively. This cell is the social optimum and the pareto optimum.

		<i>Rest of the World</i>	
		ETS	No ETS
<i>EU</i>	ETS	3	5
	No ETS	5	0

Table 1: The Game of the Green Paradox, Part 1, Given Traditional, Unilateral Green Policy

From this game essentially follows, as Sinn criticizes, that the EU is not acting as a rational player and that chances for climate change abatement are nil.

5.1.2 ... Given That Saving Helps

Payoff matrix 2 illustrates a game much like game 1, but with *some* collective benefits from unilateral saving for the climate. It assumes, that not all carbon consumption foregone by the ETS-player is used up by ROW. The degree to which this is true, notably, does not matter for this game. What matters is that there is a collective benefit, realized by the ETS-player vis-à-vis mutual defection, and that the collective benefit of mutual cooperation is not so great that defection makes no sense.

Payoffs for universal ETS or no ETS at all are the same as above. Payoffs for unilateral ETS award 1 unit to the saver, and 1 unit to the non-saver. This one unit is the *net* benefit realized from avoiding *some* global warming minus the costs borne exclusively by the party. The four units awarded to the non-ETS player are the benefits realized from avoiding *some* global warming, at no cost at all.

From this game then emerge no strictly dominant strategy, but mixed strategies. Depending on whether the other player chooses ETS or not, it will be rational to play the opposite.

According to this game, Europe and ROW are then playing rationally, with Europe bearing a greater share of the burden and some (substantial) part of social welfare not realized because of ROWs excessive (if constant) carbon consumption.

		<i>Rest of the World</i>	
		ETS	No ETS
<i>EU</i>	ETS	3	4
	No ETS	4	0

Table 2: The Game of No Green Paradox, Given Traditional, Unilateral Green Policy That Effectively Reduces Global Emmissions

If Only There Wouldn't Be a Cooperation Problem . . . It should be noted that there is third variant of the game conceivable. In that variant, payoffs for unilaterally choosing no ETS would be lower than universal ETS adoption, if so to speak, the costs of any one country not choosing an ETS in terms of the climatic damages would be so great, even when distributed among all countries, that said country would rationally adopt an ETS in the first case. The payoff for unilateral adoption of no ETS could then lie at 2 units.

Such a game would in effect assume away the common good problem of climate protection, an unlikely scenario given the “defection” observed in the real world.

5.1.3 Rationality and Time Horizons

A key question that the last paragraph raises is that of perfect rationality and time horizons. In the last instance, to a large extent the question of which of the above games approximates reality better — *aside* from the question of Sinn's Green Paradox — is which time horizon policy makers employ when writing their payoff matrices, and how rational they are.

If they have incentives to rationalize with great discounting of the future, the game becomes a cooperation problem of either type 1 or 2. If, however, players rationalize with little discounting of the future and are fully rational, type 1 should be more likely to evolve into type 2, even given just marginal collective benefits from unilateral reduction. Alternatively, of course, payoffs

could even be such that the game is one of harmony, where everyone chooses an ETS out of individual rationality.

5.1.4 The Sequential Game of Overextraction

Underlying the next game is a sequence of moves that we will simply outline here in its non-formal form. It is but a restatement of the Part 2 of the Green Paradox, outlined in the above.

If a sufficiently large country (EU) chooses grandfathered green policies, fossil fuel owners will choose a faster extraction path.

If a sufficiently large country (EU) chooses no green policies, fossil fuel owners will stick to the extraction path of the status quo.

If a sufficiently large country (EU) chooses frontloaded green policies, fossil fuel owners will choose a slower, flatter extraction path.

5.2 The Games of Choosing a Emission Regime

In the following we model the game of choosing a CO₂*e* regime, with particular regard to the intertemporal portfolio optimization of the sellers. We include in the payoffs the changing of their extraction paths in response to expected demand and price changes according to Sinn, as well as the redistributive effects that occur when a near-universal demand cartel forces sellers to sell smaller quantities at a lower price over all periods. The Green Paradox, Part I, according to which foregone consumption by one player is used by another player, until same prices and quantities are reached, is *not* included here.

5.2.1 The “Copenhagen” Game

The Game Payoff matrix 3 illustrates a hypothesized Copenhagen situation, where relatively many countries agree on an ETS, however leaving aside a substantial number of net fossil fuel exporters, or, as we will see later, population rich countries.

The two players considered here are Net Fossil Fuel Importers and Net Fossil Fuel Exporters. We choose these to concentrate on the extraction path and redistributive effects between the fossil-fuel-haves and have-nots. To that extent, it is assumed that the net fossil fuel exporters have a relatively smaller, if not negligible impact on the demand side.

The following games, in short, assume that a largely, if incompletely effective demand cartel is in place, that not all that is saved is burned by others. These games occupies a middle ground, where many countries join a

grandfathered ETS regime, but some, sufficiently large fossil fuel exporting countries stay outside the system.

The Payoffs The payoff of no regime at all is collectively and individually zero. Global warming increases as under business-as-usual.

If only the net importers choose a grandfathered green policy of some sort, both players receive a payoff of two units. In this case, aggregate carbon consumption, by virtue of the market power of the net importers, is effectively, if incompletely curtailed. Global warming slows a little, as evidenced by the collective payoff of four. However, fuel exporters sell *some* of the carbon saved elsewhere to their own consumers, albeit at a lower price over all periods. They lose some from their suppressed prices and gain some from greater fuel consumption at home. The overall net compared to the status quo is positive, they lose some revenues net, but gain a cooler planet, compared to no regime at all.

Fuel importers also benefit from slower warming, compared to the status quo, but they also lose some resources through carbon leakage outsourcing, and foregone consumption. They gain some revenues through emission trading or taxation. Their net result is also positive, compared to no regime at all.

In this situation, where sellers still find buyers, they will also frontload extraction as compared to the status quo, rightly expecting the grandfathered demand depression by the net importers. This reduces the benefits to global climate.

The exact payoffs of this cell — unilateral grandfathered green policy — are difficult to determine. These payoffs are complicated empirical question about the respective and relative sizes of the following parameters in equations 4 and 5, the details of which do not matter much for the broader argument following in the below.

$$GDP_{Exporter} = GDP_{old} + I_{CoolerPlanet} - I_{LowerFuelPrice} + I_{MoreFuelConsumption} \quad (4)$$

$$GDP_{Importer} = GDP_{old} + I_{CoolerPlanet} + I_{TaxRevenue} - I_{LessFuelConsumption} \quad (5)$$

Under a universal ETS, global warming is minimized to the greatest extent. No frontloading of extraction occurs. The extraction path becomes flatter, and lower. Collective welfare is highest at six. However, with everyone participating, the losses of depressed fuel prices over all periods that

accrue to the net fossil exporters are great. They have no additional income from more fuel consumption. Conversely, the net fuel importers gain the stabilized climate, have no costs from relatively diminished fuel consumption or carbon leakage outsourcing. They gain a lot in tax or auctioning revenue from selling emission rights.

Lastly, when only net fossil fuel exporters adopt grandfathered green policy, an unlikely scenario, they pay the price in foregone carbon consumption, which is then consumed by the rest of the world. They receive a payoff of negative two units. The collective welfare becomes negative, as frontloaded extraction exacerbates global warming⁶. The importers, however, benefit from expanded carbon consumption, from which they subtract the welfare losses of exacerbated warming, leaving them with one unit.

		<i>Net Fossil Fuel Exporters</i>	
		Grandfathered Green Policy	No Green Policy
<i>Net Fossil Fuel Importers</i>	Grandfathered Green Policy	5	2
	No Green Policy	1	0

Table 3: The “Copenhagen” or Kyoto-II Game.

The Decisions Net fossil fuel exporters have a strictly dominant strategy, which is to adopt no green policy. Knowing this, importers will adopt a grandfathered green policy, which dominates the strategy not to.

Pareto optimal will be universal green policy and unilateral green policy by net importers. The latter will also be the Nash equilibrium of this game.

The social optimum lies at universal green policy, which will not be achieved out of individual rationality.

The Implications This is a game that draws attention to the redistributive dynamics of (grandfathered) green policy, in particular the costs and gains it accrues to net fossil fuel importers and exporters.

⁶According to Sinn, as argued in the above, this scenario, akin to where only the EU adopts an ETS, may actually serve to worsen the collective payoff, by causing the net exporters to frontload their extraction.

Who are These Countries? ... is a reasonable question to ask. Aside from the fossil-fuel dominated, (rich) economies on the Arabian Peninsula, these include transition economies like China⁷, Russia, South Africa, Venezuela as well as developing countries like Iran, and some African nations.

5.3 Conclusion: Should We Believe Sinn?

We think a number of question remain as to the validity of Sinn's arguments, that we have outlined in the above.

From his thinking however emerges a strong impetus to consider the supply side of resource owners involved in reducing climate change, and unsettling findings as to the individual rationalities involved in choosing emission reduction regimes.

We believe it prudent and likely that the reality of international green political economy occupies some middle ground between Sinn, and the traditional view. Potentially, some of the CO₂ emissions saved in signatory countries to an ETS will be consumed elsewhere, but likely not all. Similarly, resource owners may not prolong their extraction paths as long as would be socially optimal, but it is unlikely that they will frontload extraction beyond reasonable measure, and it appears, their technical capacities.

Rather Safe Than Sorry To conclude, we suggest to be rather safe with (some of) Sinn, than sorry without him. Trying to come up with policy proposals in line with Sinn's warnings may cause little harm, if he is wrong, but prevent colossally detrimental failure if he is right. Additionally, we find that his insights into the redistributive dynamics of unilateral, or universal ETSs may serve to explain the empirical reality of frequent past, and likely future failure in agreeing on a global emissions reduction regime in Copenhagen 2009 and beyond.

⁷We know that China is not in fact a fossil fuel resource exporter, but subsume it here for the broader argument that follows in the below.

6 Policy Proposal

6.1 Lowering Capital Interest Rates for Fossil Fuel Money

6.1.1 “Copenhagen” Game vs. Source-Based Capital Gains Tax on Fossil Fuel Money

It emerges from the above game that the redistributive dynamics of green policy prevent greater cooperation in the field. It is then obvious to ask whether other policy solutions are available that serve the same goal of reduced emissions with less net redistribution.

Sinn himself suggests one such possibility with the source-based capital gains tax on fossil fuel investment. This policy option is not presented as a game here, because its redistributive implications are unclear.

It would be interesting to calculate however, how its redistributive impact, that should work toward the net importers, while also improving climate for everyone, compares to the payoffs in the above. Note here, that the source-based capital gain tax can be instituted with large effectiveness by the (typically developed) net fuel importers, without limited ability for evasive action by oil exporters. If its redistribution is greater than under universal green policy, it can serve as a deterrent. If it is smaller, it could be implemented to avoid at least some global warming.

6.1.2 Alternative Taxes and Inflation

Sinn points out that the capacities of a source-based capital gains tax on fossil fuel money are limited, because it can, at maximum suppress capital interest for resource owners to slightly (inflation) below zero, but not lower than that.

The question arises, which other options are additionally available to decrease capital interest for resource owners. Two options seem possible:

Increasing Savings Rate Domestically Increasing the savings rate at home should have a similar, if less concentrated effect as the above-described more specific tax. By increasing saving at home, capital demand, and capital market interest rates should fall across the board. If this is successfully implemented

Expectations of Inflation . . . should also help to increase the impact of the source-based capital gains tax, if, potentially at great cost for the domestic economy.

6.2 Redistribution

Here, we take as a starting point for a policy proposal the finding from the “Copenhagen” game that redistribution under the socially optimal configuration prevents maximum climate protection and provide suggestions for fixing that problem.

6.2.1 “Copenhagen” Game with Ex-Post Redistribution

We here present a variant of the “Copenhagen” Game, where ex-post, the collective welfare of a universal green policy is redistributed equally among the players, and both have a payoff of three units, all other things equal. The socially optimal solution then emerges as a Nash equilibrium with mutually strictly dominant strategies and is also Pareto optimal.

		<i>Net Fossil Fuel Exporters</i>	
		Grandfathered Green Policy	No Green Policy
<i>Net Fossil Fuel Importers</i>	Grandfathered Green Policy	3	2
	No Green Policy	-2	0
	1		0

Table 4: The “Copenhagen” or Kyoto-II Game, With Ex-Post Redistribution.

6.2.2 How Could This Work in Practice?

To implement this game, importers would have to credibly promise, or contractually fix said redistribution prior to, or with the adoption of universal ETS regime. If players are assumed to care about absolute, not relative payoffs, fossil fuel importers in fact have to offer only a redistributive design that leaves exporters marginally better off than under the otherwise Nash unilateral ETS of importers.

In practice, said redistribution could occur through the redistribution of emission rights to the exporting countries.

6.2.3 Is This Fair? And What About Per-Capita Emission Rights?

First of all, a redistribution of welfare to countries rich in fossil fuels may be judged to be unacceptable on normative grounds. These countries, after

all, are already blessed by nature.

This concern, as well as the importance of redistribution in the above game, raises a broader question of fairness in a global emission regime. For the redistributive problem described in the above, namely that even absent a classic collective action dynamic, countries benefit to *different* degrees from universal climate protection has wider applications.

Similar problems apply in an equivalent form to the debate concerning developing and transition economy countries versus the rich, developed countries. Also here, the costs of reducing carbon consumption, *differ*. Foregoing an additional unit of CO₂e may be much harder for transition economies, with their insatiable demand for fossil fuels, that are so direly needed at their stage in the development, resting on heavy industry, manufacture, and a massive expansion of infrastructure (think China). This of course also applies to the as-of-yet stagnant underdeveloped world, should they ever leave that stage, and unless another way to economic modernity and prosperity is conceived of.

From this, we believe, emerges a strong rationale for per-capita-emission rights⁸. Particularly if complemented by intelligent development policy, per-capita-emission rights could help to also tackle gross inequalities unrelated to global warming.

Per-capita emission rights may also be the one solution to solve the cooperation problem towards a universal emission reduction regime, much like a redistribution between net importers and exporters of fossil fuel. It may in fact, for ethical and practical reasons serve *in lieu* of the above mentioned redistribution of emission rights. Ethically, a redistribution based on the inherent equality of human beings seems more justifiable than instrumentally-rational redistributing resources to fossil fuel-rich societies, some of which are generally affluent, too (Saudi Arabia).

To see how per-capita emission rights may also help practically to largely solve the cooperation problem with oil-exporters, consider again the above list of countries. Of these, some of the largest also stand to potentially benefit from per-capita emission rights: China, Venezuela, South Africa, other african countries, Iran and possibly also Russia. What remains is a small,

⁸Held by some as greatly redistributive and revolutionary, even per-capita-*emission* rights could actually be held to be a very good deal for the developed world. The prosperity of these countries, is after all, in part a result of the carbon they have already burned during the course of their development. A radical per-capita-emission right approach may even take this already consumed carbon into account. Of course, such an approach could be rejected in terms of its intergenerational injustice, because the people who decided to pollute, and, in part, benefited from that, are no longer all alive.

and potentially negligible set of rich gulf states, whose carbon *consumption* may be deemed sufficiently negligible so as to create a de-facto demand cartel, powerful, *fair* and well-equipped to save the planet's climate.

References

- Fölster, Stefan and Johan Nyström. 2009. "Climate Policy to Defeat the Green Paradox." *Svenskt Näringsliv* .
- Gladwell, Malcolm. 2001. *The Tipping Point - How Little Things Can Make a Big Difference*.
- Hardin, Garrett. 1968. "The Tragedy of the Commons." *Science* 162.
- Sinn, Hans-Werner. 2007. "Pareto Optimality in the Extraction of Fossil Fuels and The Greenhouse Effect."
- Sinn, Hans-Werner. 2008a. *Das Grüne Paradoxon - Plädoyer für eine Illusionsfreie Klimapolitik*. Econ.
URL: [http://scholar.google.com/scholar?client=safari&rls=en&q=Das gr%C3%BCne Paradoxon+%3A Pl%C3%A4doyer f%C3%BCr eine illusionsfreie Klimapolitik&oe=UTF-8&um=1&ie=UTF-8&sa=N&hl=en&tab=ws#0](http://scholar.google.com/scholar?client=safari&rls=en&q=Das+gr%C3%BCne+Paradoxon+%3A+Pl%C3%A4doyer+f%C3%BCr+eine+illusionsfreie+Klimapolitik&oe=UTF-8&um=1&ie=UTF-8&sa=N&hl=en&tab=ws#0)
- Sinn, Hans-Werner. 2008b. "Das grüne Paradoxon - Warum man das Angebot bei der Klimapolitik nicht vergessen darf." *Perspektiven der Wirtschaftspolitik* 9:109–142.
URL: <http://blackwell-synergy.com/doi/abs/10.1111/j.1468-2516.2008.00277.x>
- Sinn, Hans-Werner. 2009. The Green Paradox. In *CESifo Forum*. Munich: .
- Stern, Nicholas. 2006. *The Economics of Climate Change - The Stern Review*.
- Taleb, Nassim Nicholas. 2007. *The Black Swan - The Impact of the Highly Improbable*. New York, NY: Random House.