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Chapter 1

Introduction

1.1 The Purpose of the Thesis

The thesis presents work on the intersection of two fields: climate change economics and resource economics. Chapters 2 and 3 make a contribution to the Green Paradox literature. The term “Green Paradox” denotes unintended adverse effects of climate policies on their environmental outcome. I set out to analyze the effects of climate policies in view of the Green Paradox, but also in view of their terms of trade and welfare effects on resource importing and exporting countries. In these chapters I account for the fact that the world is heterogeneous with respect to climate concerns: some regions employ (unilateral) policies, whereas other regions have no such policies in place. I seek to research the significance of policy heterogeneity for the effectiveness of climate policies.

In the models of Chapter 2 and 3 the success of climate policies depends on their supply side effects, i.e., on their impact on resource producers. Most of the world’s non-renewable resources, however, are state-owned or state-controlled. I try to capture the political dimension of resource extraction decisions in Chapter 4 by modelling the politician’s incentive structure and decisions in a resource-rich country. My aim is to determine the effects of political discretion over a country’s non-renewable resources on the resource extraction path.

1.2 Background

1.2.1 Climate Change Economics - The Bigger Picture

Global climate change will affect the future of humanity in the medium and in the long-term. The observed and projected increase of the earth's surface temperature is caused by the accumulation of carbon dioxide and other human-induced greenhouse gas emissions (for a meta analysis of scientific studies on global warming see Cook et al., 2013). Possible effects of this temperature change encompass increased frequencies of extreme temperature events such as heat waves, higher storm intensities, altered precipitation patterns, rise in sea-levels, and ocean current reversals. All of those changes can have severe consequences for the viability of ecosystems, biodiversity, the well-being of humans and the stability of their economic, political and social orders (Goulder and Pizer, 2006).

The prospect of global climate change emerged as a major scientific and public policy issue since the Intergovernmental Panel for Climate Change (IPCC) published its first assessment report in 1990. The goal to reduce greenhouse gas emissions in order to avert damages and costs related to the effects of global warming has been on the international policy agenda for the last 25 years. Despite the overwhelming scientific evidence that global warming is anthropogenic and that it might have severe negative consequences, there have been fierce debates on both international and national levels about which policies to introduce to mitigate climate change or whether climate action is needed at all. Attempts to introduce *global* and *unified* climate measures have not been very successful to date. On the regional or domestic level, however, various policy projects haven been taken up over the years, such as emissions trading programs, emission taxes, subsidies for renewables, performance standards, technology promoting and investment enhancing programs.

In view of the need for climate policies, it is increasingly important to gain an understanding of the theoretical economic underpinnings of climate change and to deliver both positive and normative policy analyses. The economic analysis of climate change is made particularly challenging by several complications. Firstly, climate change is a global problem, which has, however, differential impacts on different world regions. Policy benefits and costs are likely to be unevenly distributed across space and time. Secondly, the natural processes encompassing greenhouse gas emissions, such as CO₂ absorption in the oceans and its release into the atmosphere, the consequent temperature change and the appearance of damages, are slow and complex. The effects of climate change might only manifest themselves in decades

and are hence hard to estimate today. Thirdly, these processes are subject to a large degree of uncertainty: our incomplete knowledge of the earth's climate system and the existence of various feedback mechanisms render the development of reliable climate and economic models intricate. Uncertainty also extends to possible quantitative outcomes of different global warming scenarios. For instance, it is hard to guess future levels of technological development which might make mitigation and adaptation measures less costly. Another challenge is to quantitatively determine climate costs, which range from quantifiable losses in agricultural output and infrastructure destruction to less straightforward economic damage from increased mortality due to higher risk of heart diseases or malaria infections, mass migration due to sea level rise and droughts, and loss of biodiversity. Furthermore, the long-term perspective of climate change signifies that severe damages might occur only in the distant future, when the earth's population is projected to be much richer than the current generation. In view of those long-term issues, fierce debates about discount rates and the substitutability of natural capital emerged, adding a normative dimension to climate change economics.

Despite all those complexities, research in climate change economics has come a long way to help determining the optimal level of a carbon tax (Tol, 2011), in designing a carbon trading scheme (e.g. Hahn and Stavins, 1999; Springer, 2003), concerning technological change, innovation and investment decisions regarding renewable energies (Hung and Quyen, 1993; Tsur and Zemel, 2003, 2005; Valente, 2011; Acemoglu et al., 2012; Van der Meijden and Smulders, 2012), and relating to abatement and mitigation technologies.¹ Yet, many issues remain unsolved or are still inadequately addressed.

1.2.2 The Green Paradox

The combustion of fossil fuels such as oil and gas contributes largely to global carbon emissions and has been therefore targeted by various policies aimed at reducing carbon emissions. Whereas most of those measures were focused predominantly on the demand or consumer side of the fossil fuel market, Sinn (2008) directs the readers' attention to possible supply side responses to climate policies and their potential unintended adverse effects. A "Green Paradox" arises when climate policies designed to curb carbon output actually increase short-term or overall emissions. A subsidy for renewables or a fast increasing

¹Although most of the literature agrees that an optimal carbon tax should be a Pigouvian tax, disagreement exists regarding the actual social cost of carbon (SCC). For a meta-analysis on the SCC see Tol (2011).

carbon tax are simple examples of Green Paradox mechanisms: the resource owners might consider these climate policies as a threat of future expropriation, giving them an incentive to accelerate resource extraction.

Much literature on the Green Paradox has developed since Sinn's seminal paper. Gerlagh (2011) distinguishes between a Weak and Strong Green Paradox: A *Weak* Green Paradox occurs if fossil fuels are extracted more quickly in the short-run. Gerlagh (2011) refers to a *Strong* Green Paradox if the present value of the global warming costs increases as a consequence of climate policy tightening. In most standard models no Green Paradox occurs if the carbon tax is set at the Pigouvian level; the social optimum is implemented and the market is forced to internalize all climate damages from burning fossil fuels. A carbon tax, however, might be politically infeasible. An alternative is subsidizing renewables, although this typically results in a (weak) Green Paradox (Sinn, 2008; Gerlagh, 2011; Hoel, 2011; Van der Ploeg and Withagen, 2012a). A subsidized and hence more competitive backstop, however, might contribute to an earlier economic exhaustion of the fossil fuel, thereby preventing the occurrence of a Strong Green Paradox (Fischer and Salant, 2014). This is also the case if stock dependent extraction costs, implying the possibility of economic exhaustion, are considered (Van der Werf and Di Maria, 2012; Grafton et al., 2012; Van der Ploeg and Withagen, 2012a). Van der Werf and Di Maria (2012), for instance, find that Green Paradoxes are less likely to occur in models where economic exhaustion is possible.² The models can be further complicated by accounting for dirty backstops (Van der Ploeg and Withagen, 2012b) and the impact of imperfect substitutability of energy sources in the analyses (Long, 2014; Michielsen, 2014a).

The majority of these papers, however, assess the Green Paradox effect in a single economy only, thereby implicitly assuming the world to consist of homogeneous countries employing unified climate policies.³ As I have already observed above, the world is far from taking collective climate action.⁴ In reality, policies such as carbon taxation and subsidies for backstop technologies are subject to governmental discretion and political calculation. Hoel (2011) is one of the first to address this point and to research the effect of heterogeneous climate policies in a two-region model. Indeed, he finds that climate policy changes in his

²It seems that there is no alternative to economic exhaustion in the real world since the proven reserves of oil alone by far exceed the IPCC's carbon budget for global warming of 2°C.

³This also holds for most of the game theoretic literature which very often assumes the existence of one importer and one exporter bloc.

⁴The recent successes reached during the COP21 climate change conference in Paris do not in the least signify common or unified climate policies or measures.

framework result in different climate outcomes than those found in a world of identical countries and policies. Similarly, Eichner and Pethig (2011) analyze the Green Paradox in a two-period model with three groups of countries: a region using a system of tradable CO₂ permits, an unregulated region, and a fossil fuel exporter. Also Fischer and Salant (2014) incorporated a regulated and an unregulated region into their analysis of Green Paradox effects in a model characterized by multiple pools with different extraction costs.

These papers reveal that models which are limited to the analysis of a one-region world cannot capture potential interactions and emission leakages that arise in the presence of differing (levels of) climate policies between regions. This is the starting point for my Chapter 2, inspired by Hoel (2011). In addition to Hoel's two-region model with differing climate policies, I account for extra levels of heterogeneity such as differing resource extraction and backstop production costs.

Sinn (2008) and his Green Paradox idea constituted an important step towards a more complete understanding of market reactions to climate policies and their economic and environmental effects. Sinn (2008) and the bulk of his scientific offspring study the Green Paradox in a competitive market environment. Yet, fossil fuel markets, and especially the oil market, are far from being competitive. The world's largest oil producer is OPEC, a monopolistic cartel, which makes arrangements regarding resource quantities to manipulate the world oil price.

Much literature on monopolistic resource production exists (e.g. Hoel, 1978; Salant, 1977; Hoel, 1984), some of it also accounts for strategic behavior of the monopolist (Olsen, 1993; Michielsen, 2014b; Jaakkola, 2015; Kagan et al., 2015). A recurrent finding is monopolistic limit pricing. Our aforementioned critique holds also in these frameworks: the focus is on *global* policies or *unified* strategies of the consumers or resource consuming countries. Chapter 3 combines monopolistic resource production and limit-pricing behavior with the idea of heterogeneity in climate policies. The question is whether and under which circumstances Green Paradox outcomes occur in this setting. Another key aspect of this chapter is to assess whether climate policies can be effective in such a heterogeneous world.

1.2.3 Political Economy of Resource Extraction

Climate change economics and Green Paradox analyses in settings with heterogeneous climate policies are key aspects in the first part of my thesis. In the second part the focus lies on resource economics, notably the political determinants of resource extraction.

The motivation for Chapter 4 is the fact that most of the world's non-renewable resource deposits are state-owned or state-controlled: 70-80% of the world's oil and about 75% of the world's gas reserves are located in countries where the government exerts discretionary power over the resource, according to the BP Statistical Review of World Energy (BP, 2014).

The so-called "resource curse" literature relates political leadership and the quality of institutions to the bad economic performance and low economic growth of resource-rich countries. While many empirical studies confirm the existence of this relationship (Sachs and Warner, 1995, 2001; Gylfason, 2001), the theoretical literature offers a variety of possible explanatory mechanisms such as voracity of powerful groups (Tornell and Lane, 1999), rent seeking (Mehlum et al., 2006), the quality and form of government (Deacon, 2009) and corruption (Leite and Weidmann, 1999). Chapter 4 relates to the resource curse literature inasmuch it focusses on the institutional framework and political context of resource extraction. I contribute to the scarce literature which assesses the political incentives that are generated by resource endowments, such as in Robinson et al. (2006), Van der Ploeg (2011b) and Van der Ploeg (2012). In a similar vein I assume that politicians are self-interested and therefore not pure social welfare maximizers, and I examine the consequences of their discretionary decision making power regarding non-renewable resources for the resource extraction path.

1.3 Structure of the Thesis

In Chapter 2, based on Ryszka and Withagen (2014), I investigate the Green Paradox phenomenon in a two-region setting: both regions possess non-renewable resource pools which differ in their extraction costs. The analysis draws upon Hoel (2011) who analyzes potential Green Paradox outcomes of unilateral climate policies in a two-region model. I add extra layers of heterogeneity to Hoel's analysis such as differing resource extraction costs between the two regions. The analytical and numerical results suggest that a backstop subsidy in one region always results in a Green Paradox outcome, whereas a carbon tax typically does not. By conducting a calibration exercise I find that forming a 'climate coalition' and introducing carbon taxation even in the absence of real climate concerns is beneficial for the largest fossil-fuel using countries.

In Chapter 3, based on Van der Meijden et al. (2015), I combine heterogeneity in climate

policies with monopolistic resource production and limit pricing. A monopolistic resource producer faces demand from a region employing a carbon tax and a backstop subsidy, and a region which has no climate policies in place. In this setting the monopolist's optimal resource extraction path can contain two limit-pricing phases. I analyze the Green Paradox and welfare effects of changes in the climate policy parameters such as the backstop production costs, the backstop subsidy and the carbon tax. I find that initial resource consumption decreases as a consequence of climate policy tightening; no Weak Green Paradox occurs. Yet, a decrease in the backstop production cost and an increase in the backstop subsidy tend to shorten the overall extraction period, potentially resulting in higher total climate costs.

In Chapter 4 of the thesis I change the perspective from the international level of Chapters 2 and 3 to focus on the determinants of resource extraction at a national level. In particular, I analyze the consequences of state ownership or control of a country's resource pool for the resource extraction path and the society's welfare. I develop a political economy model of resource extraction where the politician's rapacity and the pace of resource extraction are ultimately determined by political economy features such as the weight the politician attaches to society's welfare, the politician's discount rate and his time horizon. These exogenous political economy features are generated endogenously in another model presented in the second part of Chapter 4: I demonstrate how the politician's discount rate and social weight endogenously follow from the politician's probability of losing power. Another result is that the absence of commitment in the endogenous model implies a further worsening of the resource extraction path compared to the solution in the exogenous political economy model or the Social Planner framework.

Chapter 5 provides a summary.