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Second-best carbon taxation in the global economy: The Green Paradox and carbon leakage revisited ☆

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ABSTRACT

Acceleration of global warming resulting from a future carbon tax is large if the price elasticities of oil demand are large and that of oil supply is small. The fall in the world interest rate weakens this weak Green Paradox effect, especially if intertemporal substitution is weak. Still, social damages from greenhouse gases drop if the fall in oil supply and cumulative emissions is strong enough. If the current carbon tax is set too low, the second-best future carbon tax is set below the first best too to mitigate adverse Green Paradox effects. Unilateral second-best optimal carbon taxes exceed the first-best taxes due to an import tariff component. The intertemporal terms of trade effects of the future carbon tax increase current and future tariffs and those of the current tax lower the current tariff. Finally, carbon leakage and globally altruistic and unilateral second-best optimal carbon taxes if non-Kyoto oil importers price carbon too low are analysed in a three-country model of the global economy.

Introduction

Badly designed climate policy can be counter-productive. For example, the Green Paradox states that politicians that put off carbon taxation bring oil consumption forward and thus accelerate global warming (Sinn, 2008). However, a future carbon tax also cuts the total amount of fossil fuel that is burnt and thus cuts cumulative carbon emissions (e.g., van der Ploeg and Withagen, 2012). Physicists have also recognized the importance of locking up enough fossil fuel in the crust of

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the earth (e.g., Allen et al., 2009). Indeed, as much as a third of oil, half of gas and over four fifths of coal reserves must be left unburnt for global warming to stay below 2 °C (McGlade and Ekins, 2015). Much of this debate on climate policy is cast in partial equilibrium. Our objective is to adopt a general equilibrium perspective taking full account of the repercussions in global markets for final goods, bonds and fossil fuel. To explain the cumulative burnt fossil fuel and carbon emissions, we model exploration investment (Gaudet and Laserre, 1988; Cairns, 1990).

We want to deepen understanding of second-best policy reform starting from a sub-optimal situation as well as global and unilateral second-best optimal carbon taxes. We distinguish oil-importing and of oil-exporting countries with homothetic, symmetric preferences.[1] Types of reform that we consider are politicians shying away from carbon taxation by putting it off and using renewable energy subsidies. We also derive and discuss second-best optimal policies when other countries including fossil fuel producers are unwilling to price carbon at the appropriate level and discuss second-best responses if there are third oil-importing countries that do not engage in climate policies.

Our contributions concerning *second-best policy reform* are as follows. First, we show that announcing to tax carbon in the future boosts current oil demand and carbon emissions. This is the so-called *weak* Green Paradox effect (Gerlagh, 2011). We show that this effect is stronger if the price elasticities of current and future oil demand are large and those of oil exploration and oil supply are small. We show that this effect is attenuated by the fall in the world interest rate, especially if intertemporal substitution is weak (cf., van der Meijden et al., 2015). The adverse effect on social damages from greenhouse gases is further mitigated by locking more carbon in the earth as a result of curbing oil exploration. If the net effect of a future carbon tax on social damages from greenhouse gases is positive, one has a *strong* Green Paradox effect (Gerlagh, 2011). We show that this occurs if the ecological discount rate is large enough while the price elasticity of oil demand is high and that of oil supply is small. Despite such a strong Green Paradox, oil-importing countries might still improve their welfare due to the import tariff and intertemporal terms of trade benefits of a higher future carbon tax.

Second, we show that, if the condition holds for a future carbon tax to induce a strong Green Paradox, an asset holding tax on oil exporters boosts welfare and is thus a good alternative. But, if oil supply reacts strongly to oil prices and demand not, a future carbon tax boosts welfare but an asset tax does not. Third, we show that subsidizing renewable energy induces weak Green Paradox effects and locks up more carbon in the long run provided renewables are a good enough substitute for oil. For future renewable subsidies these effects are attenuated in general equilibrium. In case there is an abundant and cheap alternative to fossil fuel (coal), we give conditions for which the weak Green Paradox effect is reversed (cf., Michielsen, 2014) and for which oil exporters benefit from climate policy at the expense of coal producers (cf., Coulomb and Henriet, 2015).

Fourth, we establish that introducing a carbon tax that grows at a rate equal to the rate of interest does not affect the intertemporal pattern of oil extraction if oil reserves are given. If carbon taxes rise at a faster rate than the interest rate, weak Green Paradox effects occur and social damages from greenhouse gases increase; carbon taxes that rise slower than that curb these social damages. But if oil supply is elastic, a carbon tax that rises at a rate equal to the interest rate cuts current oil extraction and cuts exploration investment, oil reserves, cumulative carbon emissions and social damages from greenhouse gases.

Our contributions concerning *second-best optimal policies* are as follows, where we use as our benchmark the global first-best carbon taxes that are set to the Pigouvian social costs of carbon (the present value of marginal global warming damages). We first show that, if for political reasons the current carbon tax is pegged below the Pigouvian tax, the global second-best optimal future carbon taxes are below the first-best globally optimal carbon taxes to mitigate weak Green Paradox effects, and more so if the price elasticity of oil demand is relatively large compared with that of oil supply (possibly turning the future tax into a subsidy). The first-best global carbon taxes rise slower than the rate of interest and thus induce no weak Green Paradox effects. We then show that if carbon taxes are set unilaterally by the oil-importing countries, they exceed the global first-best taxes as they contain an import tariff component. We also show that the intertemporal terms of trade effects of a future carbon tax increase both the current and future import tariff components and that of the current carbon tax depresses the current import tariff component. We discuss the time inconsistency of unilateral second-best optimal carbon taxes, which results from the pure rents inherent in future reserves. Unilateral reneging implies that carbon taxes are pushed up at an even greater welfare cost to oil-exporting countries.

Finally, our contributions relating to *carbon leakage* if there are third countries that pursue inadequate climate policy are as follows.[2] We show that both contemporaneous and intertemporal carbon leakage strengthen the weak Green Paradox effect as non-Kyoto countries that do not price carbon enough raise current and future carbon emissions in response to a future unilateral carbon tax. We show that social damages from greenhouse gases fall if oil supply responds more to prices than current oil demand of the Kyoto and non-Kyoto countries and if the ecological discount rate is small, but welfare of the Kyoto countries rises by more due to rent-grabbing effects. We also show that the intertemporal terms of trade effect on unilateral welfare is proportional to the future trade balance of the Kyoto countries. Finally, we derive the globally altruistic and the unilateral second-best optimal carbon taxes for the Kyoto countries given that the non-Kyoto countries price carbon below the Pigouvian social cost of carbon. The former are set too low, especially if more of the burden of carbon taxes is

[1] From now on we refer to 'oil' as shorthand for gas, coal and other components of fossil fuel.

[2] Earlier studies on carbon leakage are Elliott et al. (2010, 2012), Fischer and Salant (2013), Elliott and Fullerton (2014), Eichner and Pethig (2011, 2013), Ritter and Schopf (2014) and Sen (2015).