Energy Policy 121 (2018) 292–299

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Climate change and intergenerational equity: Revisiting the uniform taxation principle on carbon energy inputs☆

Maria Elisa Belfiori

Facultad de Ciencias Económicas, Pontificia Universidad Catolica Argentina, Av. Alicia Moreau de Justo 1400, Buenos Aires C1107AFB, Argentina

ARTICLE INFO

JEL:
Q54
Q56
H21
H23

Keywords:
Climate
Environmental equity
Optimal taxation
Environmental taxes and subsidies

ABSTRACT

This paper presents a neoclassical growth model with three energy sectors and a climate externality. Energy is used in the production of the final consumption good. The energy sectors differ on the exhaustibility of the energy resource. Oil is an exhaustible resource, coal is an abundant resource, and a green energy sector uses labor. Oil and coal use increases the stock of carbon in the atmosphere, which generates a climate externality. Standard Pigouvian taxation prescribes that a uniform tax on all carbon energy inputs is optimal. This uniform tax must be equal to the social cost of carbon because this is the externality that the usage of these inputs generates. I consider a policymaker who cares about future generations and may discount the future less than the individuals in the economy. This paper's main theoretical result is that the uniform taxation rule does not carry over to an economy with a low social discount rate. In particular, the optimal carbon tax on oil does not equal the optimal carbon tax on coal. Moreover, while the optimal tax on coal equals the social cost of carbon, the optimal carbon tax on oil follows a more general formula.

1. Introduction

Carbon emissions released into the atmosphere have a mean lifetime of about 300 years, which implies that carbon emissions are an intergenerational externality. This paper studies the optimal taxation of alternative energy sources (i.e., coal, oil, natural gas, renewables) in an economy that captures both the externality and the intergenerational aspect of climate change.

Concerns about intergenerational equity have sparked a heated debate over the choice of the social discount rate in macro-climate models. Stern (2008) argues for a low discount rate based on a desire for intergenerational equity. Nordhaus (2007), Weitzman (2007), and many others criticize this point of view. They say that the discount rate should be consistent with market returns. This paper incorporates a social welfare function that assigns Pareto weights to the welfare of future generation, which maps onto low social discounting. Thus, the relevant question is what the appropriate Pareto weights are - not what the proper social discount rate is. In that sense, there is also no right or wrong answer.

Furthermore, standard Pigouvian taxation prescribes that a uniform tax on all carbon energy inputs is optimal. This uniform tax must be equal to the social cost of carbon (SCC) because this is the externality that the usage of these inputs generates. This paper's main theoretical result is that the uniform taxation principle does not carry over to an economy with a low social discount rate. In particular, the paper shows that the optimal carbon tax on oil does not equal the optimal carbon tax on coal. Therefore, creating a ton of carbon by burning oil is not equivalent to creating a ton of carbon by using coal, even if both had the same effect on the aggregate externality. Moreover, while the optimal tax on coal equals the SCC, the optimal carbon tax on oil follows a more general formula. I theoretically characterize the optimal tax rates and show that both, the SCC and the social and private discount rates, play a role in the optimal tax on oil.

This paper develops its argument in a neoclassical growth model with three energy sectors and a climate externality. The production of the final consumption good uses energy inputs. The energy sectors differ on the exhaustibility of the energy resource. Oil is an exhaustible resource; coal is an abundant resource, and a green energy sector uses labor. Oil and coal use increases the stock of carbon in the atmosphere, which generates the climate externality.

This paper assumes that coal and oil have the same effect on the aggregate externality. However, coal emits more CO_2 than oil per unit of energy. van der Ploeg and Withagen (2012) show that, if one takes into account that coal is dirtier, it is optimal to use more oil and less coal. Similarly, Golosov et al. (2014) find that the welfare gains from the introduction of an optimal carbon tax come from the efficient use of coal, and not so much of oil. Even though oil is used up too quickly in the laissez-faire economy, the inefficient use of coal leads to substantial

☆ *"This article is part of a Virtual Special Issue entitled 'Energy and Environment: Transition Models and New Policy Challenges in the Post Paris Agreement'."*

E-mail address: elisa_belfiori@uca.edu.ar.

https://doi.org/10.1016/j.enpol.2018.06.026
Received 26 July 2017; Received in revised form 3 May 2018; Accepted 19 June 2018
0301-4215/ © 2018 Elsevier Ltd. All rights reserved.

welfare losses because the stock of coal is much larger and, therefore, leads to significant global warming. Thus, both papers conclude that coal is the real threat to climate change. In this paper, I argue that this conclusion may not carry over to climate models with social discounting. In particular, achieving intergenerational equity as a climate goal depends much more on the efficient use of oil reserves, and not so much of coal. The reason is that oil is exhaustible, and there are substantial welfare losses from passing on too little oil to future generations.

This paper is closely related to von Below (2012), Belfiori (2017) and Barrage (2018), who study the implications of social discounting on the design of optimal carbon taxes. Like von Below (2012), I also find that the social and private discount rates appear as an extra term in the optimal carbon tax formula, and that a capital income subsidy is optimal. The optimality of the capital income subsidy is also characterized in Barrage (2018). However, this paper differs from both von Below (2012) and Barrage (2018) in that I derive the policy implications of social discounting on alternative energy sources such as coal, oil and green energy. This paper borrows the approach to social discounting from Belfiori (2017). The main difference with that paper is that Belfiori (2017) considers oil as the only input in the production process and, therefore, it does not study the different policy implications of social discounting on alternative energy sources such as oil versus coal and renewable energy. This paper is also related to the literature on the optimal taxation of fossil fuels with a climate externality within a standard neoclassical macroeconomic framework, including Acemoglu et al. (2012), Barrage (2017), and Golosov et al. (2014). However, this paper differs from those papers because they do not formally study the interaction between social discounting and the optimal design of carbon policies. This paper also differs from Barrage (2017) in that I assume that the government has access to lump sum taxes. This paper relates to Belfiori (2015), Karp (2016) and Gerlagh and Liski (2018) in that all of them focus on the interaction between social discounting and the design of optimal carbon policies. Like these papers, I also find that, with social discounting, the optimal carbon tax is not equal to the social cost of carbon. However, this paper differs from those in several aspects. First, this paper restricts attention to geometric discounting, and it does not contemplate inconsistency and commitment problems. Second, this paper focuses on how the exhaustibility nature of the energy resources have an impact on the optimal carbon tax when there is social discounting.

The remainder of the paper is organized as follows. Section 2 sets up the basic model. Section 3 introduces the concept of intergenerational climate equity. Section 4 characterizes the social optimum. Section 5 describes the market outcome and contains the main results of the paper. Section 6 provides some conclusions from the analysis. Finally, the Appendix includes all the mathematical proofs.

2. Model

Consider the following version of the economy in Golosov et al. (2014). Time is discrete and infinite, $t \in \{0, ..., \infty\}$. The economy is populated by a unit mass continuum of identical individuals. There is a single consumption good that is produced using capital, labor, and energy. The production function is given by

$$\widetilde{Y}_t = F(K_t, N_{0t}, E_t) \tag{1}$$

where E_t is an energy composite. The energy components differ on the exhaustibility of the resource involved. In particular, I assume that there are three types of resources: an exhaustible resource (E_1); an exhaustible but abundant resource (E_2); and a renewable resource (E_3). According to estimates of the world reserves, the ratio of coal reserves to production is about three times larger than the corresponding ratio for oil and gas. Therefore, I will refer to sector 2 as "coal" and to sector 1 as "oil", where oil means oil and natural gas throughout the paper. The energy composite, E_t, is defined as

$$E_t = [\kappa_1 E_{1t}^{\rho} + \kappa_2 E_{2t}^{\rho} + \kappa_3 E_{3t}^{\rho}]^{1/\rho} \tag{2}$$

where $\sum_{i=1}^{3} \kappa_i = 1$, and the parameter ρ represents the elasticity of substitution between the energy components. According to the metastudy in Stern (2010), this elasticity is low at the macro level, and somehow larger at the industry level. The elasticity of substitution is higher between coal and gas, and lower for oil. The elasticity of substitution is also higher in power generation and lower in other uses such as transportation. The elasticity of substitution between the energy components does not affect the theoretical results in this paper, although it can be important quantitatively as shown in Golosov et al. (2014).

The energy components are produced according to their own technology. Oil is an exhaustible resource, and it is costly to extract. At each point in time, oil use equals total oil extraction

$$E_{1t} = R_t - R_{t+1} \tag{3}$$

for every period t. The extraction cost is stock-dependent and given by $g(R_t)$ where g is an increasing, convex, and differentiable cost function. Furthermore, the extraction cost is in units of the final consumption good. The economy starts with an initial stock of oil, R_0.

Coal is also finite, but it is assumed to be an abundant resource. Hence, there are no scarcity rents associated with coal use. Moreover, coal energy is produced using labor according to the function

$$E_{2t} = A_{2t} N_{2t} \tag{4}$$

where A_{2t} is productivity in the coal sector.

Renewable energy production also uses labor and has sector-specific productivity given by A_{3t}. Thus,

$$E_{3t} = A_{3t} N_{3t} \tag{5}$$

The sub-index t in the productivity parameter indicates the possibility of technical change. This change can be an improvement in the available technologies but can also reflect a slowdown in the development of new techniques. The technological change is exogenous.

Oil and coal use increases carbon in the atmosphere, S_t. In particular, carbon in atmosphere in every period t evolves according to

$$S_{t+1} = (1 - \gamma) S_t + E_{1t} + E_{2t} \tag{6}$$

where $\gamma \in [0, 1)$ is the natural rate of carbon reabsorption and the economy starts with a stock of carbon S_0. The stock of carbon in the atmosphere generates a climate externality that takes the form of an output loss. Thus, total output with the climate externality is given by

$$Y_t = x(S_t) F(K_t, N_{0t}, E_t) \tag{7}$$

The damage function x is decreasing, convex and twice differentiable with $\lim_{S \to 0} x(S) = 1$ and $\lim_{S \to \infty} x(S) = 0$.

Individuals derive utility from consumption and discount the future with the discount factor $\beta \in (0, 1)$. Over time, individuals care about the value

$$\sum_{t=0}^{\infty} \beta^t u(C_t) \tag{8}$$

The utility function u is increasing, concave and twice differentiable with $\lim_{c \to 0} u'(c) = \infty$. Individuals consume, work and invest in capital. Capital depreciates at rate δ and evolves according to the law of motion

$$K_{t+1} = (1 - \delta) K_t + I_t \tag{9}$$

The economy starts with an initial stock of capital K_0. The feasibility constraints in this economy are given by

$$C_t + K_{t+1} + g(R_t) = Y_t + (1 - \delta) K_t \tag{10}$$

$$N_t = \sum_{i=0}^{3} N_i \tag{11}$$

Download English Version:

https://daneshyari.com/en/article/7396879

Download Persian Version:

https://daneshyari.com/article/7396879

Daneshyari.com