



Contents lists available at ScienceDirect

International Review of Economics and Finance

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

Slowing resource extraction for export: A role for taxes in a small open economy

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ARTICLE INFO

Keywords:

Resource extraction

Small open economy

Taxation

Capital installation costs

ABSTRACT

This paper develops model of a small open economy with installation costs of capital to analyze how taxes could slow extraction of resources for export. The overseas combustion of depleted resource stocks contributes to global warming, which impedes productivity growth in the small open economy. We find that the optimal resource depletion rate is independent of the social welfare function and discount rate. An export revenue tax rate need not fall over time to curb depletion if capital gains are taxed at a lower rate than interest income. The analysis is robust to installation costs of capital and transitional dynamics. The findings challenge conventional wisdom and suggest an array of tax policies for a small open economy seeking to curb extraction of resources for export.

1. Introduction

Small open economies, rich in fossil fuels that are non-renewable and exported for combustion overseas, both contribute to and are affected by global warming. Norway, for example, is one of the world's top ten oil exporters and has recently witnessed fast receding glaciers and rising sea levels in the high Arctic. More than 90 per cent of known oil reserves are concentrated in small open economies (BP, 2016). At current extraction rates, worldwide reserves could last around 50 years. To put this in perspective, if human civilization as we know it was scaled to fit in a 24 hour day, oil stocks will run out in less than 15 min. This paper analyzes how taxes in a resource-rich small open economy could slow the extraction of non-renewable resources for export.

The Paris agreement calls for 195 nations to contain the increase in the global average temperature to 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C. However, policies to reduce demand for fossil fuels, which focus on the point of combustion, have yet to put carbon dioxide emissions on a course consistent with global warming targets under this agreement.

If climate change objectives are to be met, a significant fraction of fossil fuel reserves must be left in the ground (McGlade & Ekins, 2015). A growing literature therefore proposes supply-side policies aimed at slowing the extraction of fossil fuels (Faehn, Hagem, Lindholt, Maeland, & Rosendahl, 2017; Harstad, 2012; Sinn, 2008). This is a theme developed in this paper, which focuses on the effect of taxes on the rate at which fossil fuels are extracted for export by a growing small open economy.

The territorial emissions of a resource exporter, in aggregate terms, may constitute a small and declining share of global emissions. However, Levitt, Pedersen, and Sorensen (2015) find that the actual emissions of a small open economy are considerably larger when significant emissions embodied in international trade are included. Dong, Wang, and Guo (2016) find that developed countries contribute much more to climate change than is shown by territorial emissions by recognizing the emissions embedded in final consumption goods exported by major emerging economies, such as China. Equivalently, there are emissions embedded in resources exported by

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<http://dx.doi.org/10.1016/j.iref.2017.12.001>

Received 9 February 2017; Received in revised form 26 November 2017; Accepted 4 December 2017

Available online xxxx

1059-0560/© 2017 Published by Elsevier Inc.

developed small open economies, such as Norway. Thus, the model developed in this paper recognizes that the resource exports of a developed small open economy contribute to climate change.

Two questions arise for a resource exporting small open economy. First, what is the socially optimal extraction rate of non-renewable resources for export when the depletion of stocks for export contributes to global warming? Second, how could taxation in a small open economy attain the socially optimal extraction rate? Our analysis considers taxes on interest income, capital gains and revenue from resource exports.

The question of how taxation can achieve socially optimal management of resources is essentially intertemporal because the stock of resources is non-renewable and therefore depleted over time as the resource is extracted. The seminal theoretical work of [Stiglitz \(1974\)](#) and [Dasgupta, Eastwood, and Heal \(1978\)](#) provides insights into the effect of taxation on exhaustible resource management in a partial equilibrium. Notably, equal tax rates on capital gains and interest income and a constant ad valorem tax rate on a non-renewable resource which is costless to produce do not distort resource extraction.

Recent literature explores these insights in general equilibrium growth models where global warming impedes productivity to analyze socially optimal tax settings ([Groth & Schou, 2007](#); [Sinclair, 1994](#); [Uplh & Ulph, 1994](#)). Taking the lead of [Stiglitz \(1974\)](#), the analysis is confined to a closed economy. This literature finds that the socially optimal extraction rate depends on the intertemporal elasticity of substitution, which is difficult to estimate, and a constant time preference rate, which is a sensitive assumption ([Guest, 2014](#)). Socially optimal extraction calls for a continuously declining rate of tax on resource use when productivity is increasing in the resource stock and extraction costs are zero. The interest income tax rate does not affect extraction in equilibrium because the rate of interest is endogenous in a closed economy growth model.

Useful implications for global agreements on demand-side policies, such as a carbon tax, are readily obtained by interpreting closed economy models as applying to the world as a whole. However, the closed economy assumption precludes analysis of supply-side policies from the perspective of a small open economy.

Moreover, the conventional wisdom that the socially optimal tax rate should fall over time is yet to be explored in a small open economy growth model. [Dasgupta et al. \(1978\)](#) show that Hotelling rule, whereby the value of resources in the ground increase over time at the rate of interest, can be applied to the optimal management of non-renewable resources in a small open economy which takes the world interest rate as given. However, insights on the effect of taxes in a partial equilibrium have yet to be explored in a general equilibrium growth model where resource depletion contributes to global warming. The present paper develops such a model to analyze the setting of taxes on export revenue, capital gains and interest income to attain socially optimal extraction of non-renewable resources for export.

The objective of this paper is to design a tax regime for a small open economy that internalizes the contribution to global warming from resources extracted for export. We focus on providing an incentive to defer extraction and leave stock of the exported resource in the ground unburned. With this objective and focus in mind, we develop a model of a growing resource rich small open economy referred to as the ‘Kuwait’ model ([van der Ploeg, 2010](#)) which assumes resources are not used in domestic production and perfect capital mobility at a given world interest rate.

It is important to note the implications of these assumptions. Composition effects in the domestic economy arising from policies that alter relative costs and comparative advantage are a pressing issue in environmental regulation ([Cole & Elliott, 2003](#)). We therefore discuss how a tax regime designed to curb extraction for export could induce the resources sector to substitute from exports to supplying domestic demand. The literature assumes instantaneous capital adjustment to focus on the relationship between stocks of net foreign assets and non-renewable resources. In fact, if capital is not used in domestic production, we have a rentier economy which uses its resource wealth to buy foreign assets.

This paper extends the existing literature in three respects. First, the model of a decentralized small open economy in this paper is capable of analyzing the optimizing behavior of firms who pay an ad valorem tax on resource exports and households who pay capital gains tax on wealth stored in resource stocks and interest income on capital holdings. Second, a negative externality from global warming is incorporated whereby the extraction of resources for export diminishes the stock, which reduces domestic productivity and thus capital accumulation which drives growth in domestic output. A social planner internalizes this externality and recognizes the social cost of extraction when managing the rate at which resources are extracted for export so as to maximize social welfare. Taking the lead of [Sinclair \(1994\)](#), socially optimal tax settings render the extraction rates under decentralized decision making and social planner equivalent, and thus correct for the negative effect of global warming on domestic productivity. Finally, we introduce installation costs of capital to assess the robustness of our results to transitional dynamics.

Two particularly interesting results of the analysis in this paper are, firstly, that the socially optimal extraction rate of resources for export equals the price elasticity of export demand times the difference between the world interest rate and marginal social cost of extraction. This finding, in contrast to socially optimal extraction in closed economy models, provides an estimable target for policy-makers. Secondly, the socially optimal extraction rate can be attained by equating the interest income and capital gains tax rates and the intertemporal rate of decline in the resource revenue tax rate to the marginal social cost of extraction, measured as the marginal domestic product from unextracted stocks relative to the marginal revenue from resource exports. Alternatively, if interest income is taxed at a sufficiently higher rate than capital gains, then the socially optimal extraction rate is attained by setting the resource revenue tax rate to rise over time. These results provide an array of socially optimal tax settings for a resource rich small open economy seeking to curb the depletion of non-renewable resources for export.

2. Small open economy model of resource depletion

Consider a small open economy endowed with resources which are sold on the world market at a price, p_t , according to the inverse

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