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Maximum Carbon Taxes in the Short Run

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Abstract: A cap is imposed on the carbon tax rate if the total tax revenue is not allowed to increase. Using recent data on the carbon-intensity of the economy and the overall tax take, I show that this cap constrains almost any climate policy in at least some countries. A larger number of countries, emitting a substantial share of global carbon dioxide, cannot fully participate if the carbon tax (or equivalent alternative regulation) is high enough to meet the 2ºC target. For that target, the carbon tax revenue in 2020 is greater than 10% of total tax revenue in every country.

JEL Classification: H21, Q54

Key Words: climate policy, carbon tax, target setting

1. Introduction

There have been many calls for a sharp reduction of greenhouse gases. Economists have called for high carbon taxes (Ackerman et al. 2010;Ayres and Walter 1991;Stern et al. 2006). (Weitzman 2009) even argues for an arbitrarily high carbon tax. This seems to be in line with Article 2 of the United Nations Framework Convention on Climate Change, which calls for emission reduction so as to avoid “dangerous anthropogenic interference with the climate system”. However, Article 2 also has that “economic development [should] proceed in a sustainable manner”. This paper estimates the maximum carbon tax that can be borne in the short run.

The carrying capacity for carbon taxation is not known. In fact, the concept itself is undefined. In a democracy, one could say that a carbon tax is unlikely to exceed the level that would lead to a government defeat at the next elections. This would be hard to quantify. One can, however, estimate the willingness to accept carbon taxes. The average European is prepared to a carbon tax of $37/tC (Hersch and Viscusi 2006), 57% of Australians are prepared to pay $79/tC or more (Carson et al. 2010), and the median Harvard student would pay $210/tC (Viscusi and Zeckhauser 2006). In this paper, I take a different approach.

Assuming that climate policy will be implemented through fiscal measures, I compute the maximum carbon tax that is budget neutral. That is, what would the carbon tax rate be if it were the only tax, and if total tax revenue is kept constant? This obviously puts an upper bound on the carbon tax. I show below that this is a meaningful upper bound.

One can argue that, as a carbon tax aims to reduce emissions, it would not be fiscally prudent to shift the entire tax burden onto greenhouse gas emissions. One can argue that a prudent tax base is diverse (Atkinson and Stiglitz 1976;Cremer et al. 2001). Those are valid arguments. They only sharpen the conclusions below.

One can also argue that climate policy is broader than taxation. Indeed, carbon taxes have played a minor role in abatement policy. If subsidies were the policy instrument of choice, total tax revenue imposes a constraint. If tradable permits are used, then the total tax take provides a useful yardstick for the net amount that people and companies pay for permits. And total tax revenue even provides a useful yardstick if greenhouse gas emissions are reduced by direct regulation. There is a carbon tax that has the same impact on emissions as any regulation – but the economic burden of that regulation is at least as high as that of the equivalent carbon tax (Baumol 1972;Baumol and Oates 1971). Total tax revenue is thus a meaningful upper bound for climate policy, regardless of its implementation.

This note proceeds as follows. Section 2 presents data and methods. Section 3 discusses the results. Section 4 concludes.

2. Data and method

The method used is straightforward. Equate carbon tax revenue to total tax take, and solve for the carbon tax:

(1) $$t\left[\frac{\$}{\mathrm{tCO_2}}\right] M \left[\frac{\mathrm{tCO_2}}{\mathrm{yr}}\right] = \tau[\%] Y \left[\frac{\$}{\mathrm{yr}}\right] \Rightarrow t^* = \frac{\tau}{100}\frac{Y}{M}$$

where t is the carbon tax (in dollars per tonne of carbon dioxide), M is carbon dioxide emissions (in tonnes per year), τ is total tax take (in per cent), and Y is gross domestic product (in dollars per year).

The maximum carbon tax t^* is then equal to the tax take τ times the inverse of the carbon intensity of the economy M/Y.

Over time, a carbon tax would reduce emissions and improve the carbon intensity of the economy. Equation (1) only holds in the short run.

Data are readily available. I used the World Bank's Development Indicators[1], which is freely available and contains data on all elements of Equation (1). Economic data are in constant 2000 US dollars, using market-exchange rates. Carbon dioxide emissions are for fossil fuel combustion and cement production only. I used data for 2005, the most recent year with almost complete coverage.

3. Results

Figure 1 shows the survival function of total carbon dioxide emissions in the carbon tax. Figure 1 should be read as follows. If the carbon tax is zero, all countries meet the criterion that the carbon tax is less than the maximum carbon tax. The (zero) carbon tax covers 26 billion tonnes of carbon dioxide.[2] As the carbon tax increases, it exceeds the maximum carbon tax for an increasing number of countries. These countries drop out, and the carbon tax covers an ever smaller share of the 26 $GtCO_2$.

The numbers in Figure 1 are intriguing. The maximum carbon tax is less than $1/$tCO_2$ for Liberia and Nigeria. Both countries collect less than 1% of GDP in taxes. The maximum carbon tax for the Ukraine is $23/$tCO_2$, primarily because its economy is so carbon-intensive. The maximum carbon tax for China is $29/$tCO_2$, as its tax take is relatively low and its carbon-intensity relatively high. The maximum carbon tax is $36/$tCO_2$ for Russia and $45/$tCO_2$ for India.

For Brazil, the maximum tax is $353/$tCO_2$ as its economy is relatively carbon-extensive – recall that land use emissions are excluded. That tax covers only 14% of emissions, however. The median of the maximum tax is $200/$tCO_2$ – close to the maximum carbon tax of Hungary (just below) and Canada (just above). The maximum carbon tax of the USA is $223/$tCO_2$ – at the 75 percentile.

The four countries of Scandinavia are all in the top 5, together with Macau. Scandinavia combines high taxes with a high penetration of renewables. Iceland's maximum carbon tax is the highest, at $1367/$tCO_2$.

Figure 2 relates the maximum carbon tax to the carbon intensity of the economy (left panel) and to the tax take (right panel). Both are important, but carbon intensity is the main driver of the results. A carbon tax would have a greater impact on the fiscal system in countries that collect

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[1] http://data.worldbank.org/indicator

[2] These are the total emissions of carbon dioxide from fossil fuel combustion and cement production in 2005 for the 123 countries for which data are available on emissions, GDP, and tax revenue.

little tax. A carbon tax would pose a higher short-term burden on a more carbon-intensive economy.

Figure 3 shows the same information, but now as an inverted supply curve. Three price levels are shown. (Clarke et al. 2009) synthesize the results of a model comparison exercise on the costs of greenhouse gas emission reduction, focusing on ambitious stabilization targets. Following (Tavoni and Tol 2010), I fit a regression model to the results for the carbon tax in the near-term. This accounts for the missing observations. The fitted model is

$$(2) \qquad \ln(T) = 11.8(1.0) + 0.909(0.213)P + 0.577(0.255)E - 0.0163(0.0020)L$$

where T is the carbon tax in 2020 required to meet stabilization level L in 2100; E is a dummy for scenarios in which the target level is not exceeded in the interim; and P is a dummy for scenarios with delayed participation of developing and emerging economies. Numbers between brackets are standard deviations. There are 78 observations. The adjusted R^2 is 52%.

Equation (2) has that, with all countries participating in climate policy and approaching the target from below, a stabilization target of 650 ppm CO_2 equivalent would require a carbon tax of \$6/tCO_2e, in all countries, on all emissions, of all gases. A target of 550 ppm CO_2e would require a tax of \$29/tCO_2e, and a 450 ppm target would need a \$143/tCO_2e tax. These are the three price levels shown in Figure 3.

If the carbon tax is \$6/tCO_2e, its revenue would exceed 100% of total tax revenue in countries that account for less than 0.5% of total emissions. If the threshold is 10%, 3.5% of emissions would be excluded. In countries representing 73% of emissions, the carbon tax would yield less than 1% of current revenue. This tax and target are feasible from a fiscal perspective.

The revenue of a \$29/tCO_2e carbon tax would exceed 100% of total tax revenue in countries that account for almost 2% of total emissions. However, for a 10% threshold, almost 21% of emissions would be out of reach. Equation (2) has that the carbon tax would then need to be raised to some \$72/tCO_2e to maintain the same target – but this would exclude countries with another 7% of emissions. The carbon tax revenue is greater than 1% of total revenue in all countries.

For \$143/tCO_2e, the carbon tax revenue is greater than 100% of tax revenue for more than 10% of emissions; and greater than 10% for all countries. Such a carbon tax would not be fiscally prudent in many economies. \$143/tCO_2e is the tax needed to meet the 450 ppm CO_2e target, which roughly corresponds with the 2°C target of the EU and UN (den Elzen et al. 2007).

4. Discussion and conclusion

In this paper, I consider climate policy from a different angle, comparing the revenue of a hypothetical carbon tax to the total tax revenue of a country. I find that a simple rule – total tax take should not increase – excludes a small number of countries from a modest climate policy, but a more substantial number if climate policy aims for the nominal targets of the European Union and the United Nations. If the rule is stricter – there should be more to taxation than a carbon tax alone – ambitious targets cannot be achieved.

The analysis presented here is straightforward, using readily available data. It may be better to consider total government income rather than total tax revenue, or to compare carbon taxes to other indirect taxes only. Other greenhouse gases should be added to the analysis. More importantly, the analysis is static. A dynamic analysis would be more informative, but require three additional elements, viz., scenarios of future carbon intensities, the impact of emission pricing on carbon intensities, and scenarios of total tax revenues. Because the carbon-intensity of economies tend to fall over time, and more rapidly so in more carbon-intensive economies (Liddle 2010;Romero-Avila 2008), the problems identified for 2005 should be less pronounced in the future. The analysis disregards distributional issues. Energy is a necessary good, and carbon taxes fall more heavily on the poor (Rausch et al. 2010). It may be that a particular carbon tax is acceptable at the country average, but unacceptable from a social justice perspective. These issues are deferred to future research.

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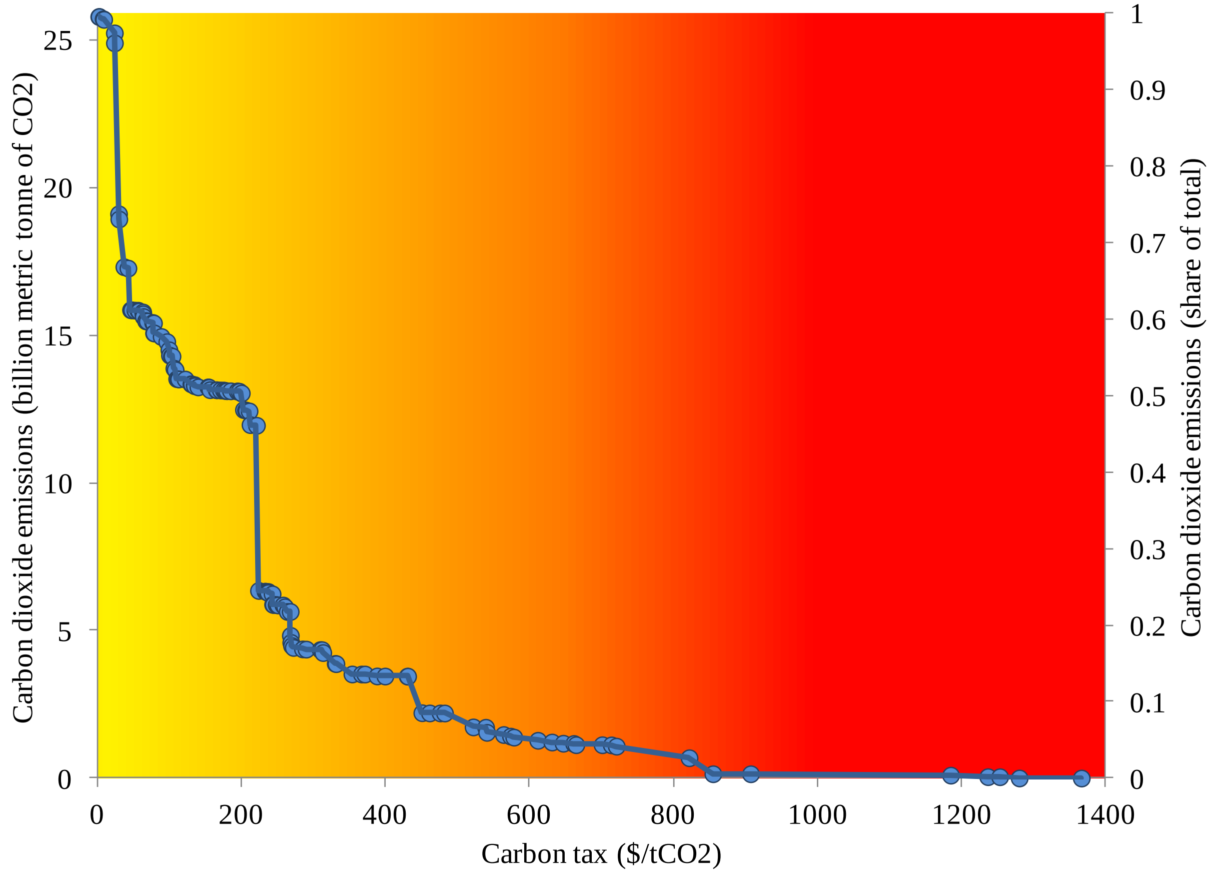

Figure 1. The survival function of total carbon dioxide emissions in the carbon tax in levels (left axis) and shares (right axis).

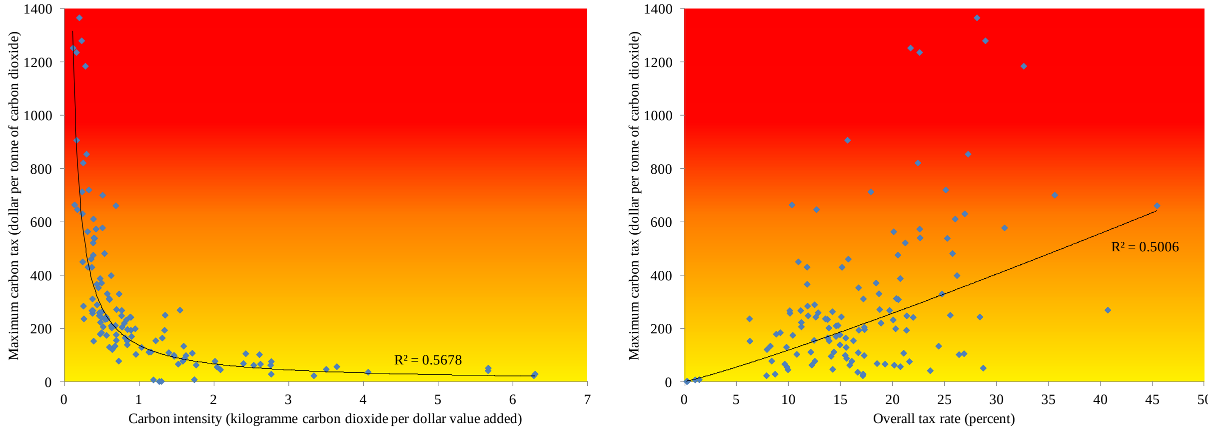

Figure 2. The relationship of the maximum carbon tax to the carbon intensity (left panel) and the tax take (right panel).

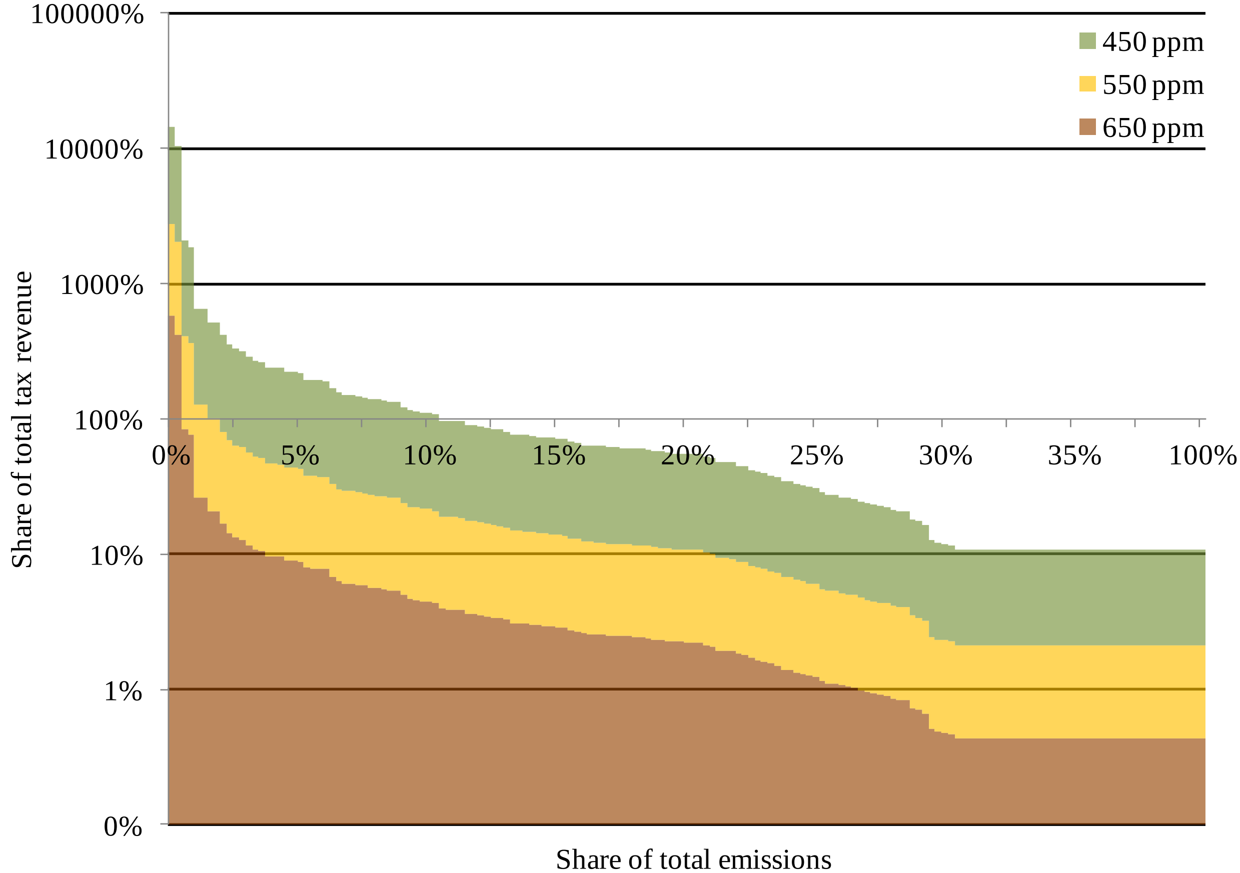

Figure 3. The survival function of the total tax revenue for three alternative carbon taxes (corresponding to three alternative stabilization targets for greenhouse gas concentrations) in the share of total carbon dioxide emissions.