UNIVERSITY
OF SUSSEX

ECONOMICS

Working Paper Series

No. 07-2017

The Private Benefit of Carbon and its Social Cost

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Abstract: The private benefit of carbon is the value, at the margin, of the energy services provided by the use of fossil fuels. It is the weighted average of the price of energy times the carbon dioxide emission coefficient, with energy used as weights. The private benefits is here estimated, for the first time, at \$411/tCO$_2$. The private benefit is lowest for coal use in industry and highest for residential electricity; it is lowest in Kazakhstan and highest in Norway. The private benefit of carbon is much higher than the social cost of carbon.

JEL classification: Q54

Key words: private benefit of carbon; social cost of carbon; climate policy

Introduction

There is a public and academic debate about the social cost of carbon (Pizer et al., 2014, Greenstone et al., 2013, Guivarch et al., 2016, Havranek et al., 2015, Hahn and Ritz, 2015, Burke et al., 2016). This focus on the damage done by emitting an additional tonne of carbon dioxide sometimes drowns out the gains from cheap and abundant energy. The risks of climate change and the need for climate policy should be discussed, but it is should not be forgotten that affordable and reliable energy is a great good – just like a stable climate is a great good. Unfortunately, in the absence of government intervention, fossil fuels continue to be the cheapest source of energy (IEA, 2016d). I quantify the private benefit of using carbon-emitting energy and show that, in most cases, using fossil fuel adds more value than it destroys.

Methods and data

Economists have long theorized about value and how to measure it, but the debate was settled by Jevons in 1871 (Jevons, 1871). In an undistorted market, with rational and well-informed consumers and producers, the price of a good equals its marginal value (Mankiw, 2014). We are only prepared to buy something if the welfare gain of getting it is greater than the welfare loss of giving up part of our income and thus the opportunity to buy something else. Vice versa, we are only prepared to sell something if the price we get exceeds the loss we suffer from no longer owning it – for instance because the money gained allows us to buy something we appreciate better. The price of energy is thus a measure of the marginal value of energy – or rather of the services delivered by energy, such as warmth, cooked food, mobility and communication. The same is true for energy used by companies. The price paid for energy equals its marginal productivity, which in turn equals the marginal value of the products and services produced with this energy (Mankiw, 2014). The price of energy is therefore, at the margin, a measure of the worth of energy.

The social cost of carbon is the damage done by emitting an additional tonne of carbon dioxide (Tol, 2011). Technically, the social cost of carbon is the net present value of the incremental future impact of climate due to a small change in emissions today. Like the price of energy, the social cost of carbon is a marginal concept – and the two are directly comparable. Indeed, the social cost of carbon is the climate incarnation of the Pigou tax (Pigou, 1920), which is conceptualized as the price correction needed, through a levy, so that private incentives (as measured by the price) are aligned with social objectives (as measured by Pigou tax) (Baumol, 1972).

While conceptually clear, measuring the price of energy is complicated. Energy comes in a dizzying variety, from donkeys and dried cow pats to high octane gasoline and direct methanol fuel cells. The price of homogeneous fuels can vary sharply over space, as any car driver can attest, and between suppliers, as a quick glance at any price comparison website will show. Some retail prices change daily, other prices are fixed for a year. Some prices are public knowledge, other prices are commercial secrets. There are discounts and special deals, general and targeted price subsidies, taxes, tax exemptions and tax rebates. There are black markets and clandestine production. There are direct imports and fuel smuggling. These difficulties notwithstanding, the International Energy Agency has published average energy prices for the main energy carriers and the main energy users for all countries of the OECD (IEA, 2016b) and selected other countries (IEA, 2012). In most cases, the IEA worked closely with national statistical offices to collect data in a standardized format; in some cases, commercial agencies were involved, following the IEA guidelines.

Data are available for 66 countries. Most recent data are for 2010. After that, coverage is limited to the countries of the OECD. The 2010 data cover 57% of world total final fossil fuel and electric energy use. The main missing data are probably for the use of solid fuels for home heating and cooking. Data are reported as 2010 US dollar per unit of energy. Multiplied by the inverse of the emission coefficient – tonnes of carbon dioxide emitted per unit of energy – a carbon price in tonnes of CO_2 per dollar for each fuel, use and country readily follows. I compute the weighted average across fuels, uses, and countries using final energy use as weights.

Energy prices are taken from the IEA energy price statistics for 2010 for OECD countries and selected non-OECD countries (IEA, 2012) and for 2014 for OECD countries.(IEA, 2016b) Energy prices are reported in current US dollar per unit. Prices were converted to constant 2010 dollars using the all-item consumer price index (BLS, 2016). Explicit energy prices were converted to implicit carbon prices using EIA emission coefficients (EIA, 2016), except for LPG and electricity, where emissions coefficients from the EPA (EPA, 2014) and the IEA(IEA, 2016a), respectively, were used. Energy use for 2010 (IEA, 2013a, IEA, 2013b) and 2014 (IEA, 2016c) was taken from the IEA energy balances.

These conversions are imprecise. Statistics on energy prices, energy use and emission coefficients are reported for different aggregates of fuels. This is particularly the case for solid and liquid fuels, which exist in multiple forms and varieties. The energy balances have the coarsest resolution: solid, liquid and gaseous fuels and electricity for industry, and liquid and gaseous fuels and electricity for residential. For solid and liquid fuels the minimum and maximum prices were used to put a lower and upper bound on the aggregate.

The reported range is therefore no indication of the uncertainty about the estimate of the private benefit of carbon. The IEA, the main source of data, does not report a statistical or any other measure of the uncertainty about their price or use statistics. Data are gathered by survey and thus subject to sampling error and perhaps non-sampling error (Weisbert, 2005). Unfortunately, no attempt has been made to quantify measurement error.

Results

These calculations show that the private benefit of carbon is lowest for coal use in industry: \$38-65/tCO_2. It is highest for residential electricity use: \$1,877/tCO_2. The private benefit of carbon is lowest in Kazakhstan: \$48-67/tCO_2. It is highest in Norway \$6,241-6,277/tCO_2. The global average is \$382-440/tCO_2 or \$1,402-1,621/tC.

There have been many estimates of the social cost of carbon. The mean of published estimates is \$12/tCO_2 for studies that use a 3% pure rate of time preference, and \$98/tCO_2 for studies that use a 1% pure rate of time preference (Tol, 2015). This is low compared to the private benefits estimated above. Figure 1 shows the cumulative histogram, by user, fuel and country, of the private benefit of carbon, weighted as above by fuel use. The private benefit of 0.6% of fossil energy use is less than the lower estimate of the social cost of carbon. For the higher estimate, 9.8% has a private benefit that is lower than its social cost. In other words, 0.6% or 9.8% of fossil energy use destroys more value than it adds. More than 90% of fossil energy use adds more value than it destroys.

There is an alternative interpretation to Figure 1. If a carbon tax is imposed equal to the lower estimate of the social cost of carbon, 0.6% of end-use energy prices would more than double. Other energy prices would rise less. If pre-announced and phased in, such a price rise would have only a modest economic impact (Clarke et al., 2014, Weyant, 1993). On the other hand, for the higher estimate of the social cost of carbon, 9.8% of energy prices would more than double. The CDF shown in Figure 1 also implies 36.8% would see an increase of more than 50% if the higher estimate of the social cost of carbon would be imposed as a carbon tax, and 88.1% a price rise of more than 20%. If such a carbon tax would be imposed, energy use would fall and the private benefit of carbon would rise.

In the middle of February 2017, the price of CO_2 emission permits was \$5.20/tCO_2 in the EU Emissions Trading System and \$13.51/tCO_2 in California, while CDM Certified Emission Credits traded at \$0.30/tCO_2. The clearing price in the latest RGGI auction in December 2016 was \$3.55/tCO_2. These carbon prices have a modest impact on the majority of energy prices.

Discussion and conclusion

These estimates corroborate one of the key findings of the literature on greenhouse gas emission reduction: Well-designed climate policy does not have a large, negative impact on economic growth (Clarke et al., 2014). It cannot, because the end-use price of energy does not increase by much and energy is, in most cases, only a small share of business and household expenditure. Furthermore, carbon permits create new revenue too, for the government in case permits are auctioned and for emitters in case of grandparenting. Such revenue at least partially offsets the negative economic impact of more expensive energy (Bovenberg and de Mooij, 1994, Bovenberg and Goulder, 1996).

The current paper does not cover greenhouse gases other than carbon dioxide. In principle, the methods used here can readily be applied. However, particularly for methane and nitrous oxide, emissions of which are primarily tied to agriculture, the practical problems are, for now, insurmountable. Although information on food prices is improving, particularly for countries that suffer food shortages (WFP, 2017) and life-cycle analyses of food products are getting more comprehensive, particularly for rich countries (Scarborough et al., 2014), at the time of writing there are no reasonably representative databases on food prices, food consumption, and emission coefficients.

While the focus of this paper is on the private benefits of carbon, there may be wider implications of energy use, which are closely linked to development (Dinkelman, 2011, Allcott et al., 2016, Ozturk, 2010). For instance, electrification is known to improve schooling (Khandker et al., 2014). The above estimate is correct if parents fully incorporate their children's prospects in their decision to purchase electricity. If not, the above estimate is a lower bound to the true private benefit of carbon. One may also argue that schooling improves not just career prospects, a private benefit, but also political freedom (Barro, 1999, Glaeser et al., 2007, Acemoglu et al., 2005), a social benefit. Again, the above estimate would be a lower bound. However, welfare effects are estimated at the margin, and the effect of an additional kiloWatthour on democracy is rather small.

Other impacts of energy use are well-known, including outdoor air pollution (Lelieveld et al., 2015) and congestion (Parry et al., 2007). As with climate change, these externalities do not diminish the *private* benefits of energy use, but they do drive a wedge between the *social* and the *private* welfare effects.

Indoor air pollution (Jones, 1999) is a different matter, as it primarily affects the families who also enjoy the energy services (Larson and Rosen, 2002, Hanna et al., 2016, Edwards and Langpap, 2012). Indoor air pollution is therefore largely a *private* cost, although some effects spill into the public domain through poor health and poor schooling. However, this does not really affect the estimate above, as it excludes solid fuels used in households and thus the main source of indoor air pollution.

The private benefit of carbon is large and, in most cases, much larger than the social cost of carbon. But while the social cost of carbon is tied to carbon dioxide emissions and their impact on the climate, the private benefit of carbon is not tied to fossil fuels. The private benefits of carbon are, really, the benefits of abundant and reliable energy – or rather, the benefits of the services provided by energy, such as warm homes, cooked food, travel and transport, information and communication, and so on. An increasing share of these benefits can be had without incurring carbon dioxide emissions, or by paying a falling premium to avoid such emissions.

Table 1. Private benefit of carbon, in ^{2010}\$/tCO$_2$, average over countries and fuel using final energy use as weights.

	2010, World	2010, OECD	2014, OECD
Industry			
Coal	38-56	44-77	41-67
Oil	258-434	210-520	245-555
Gas	143	149	164
Power	532	488	676
Residential			
Oil	360-651	405-754	451-752
Gas	322	324	318
Power	780	757	1073
Average	382-440	388-442	499-544

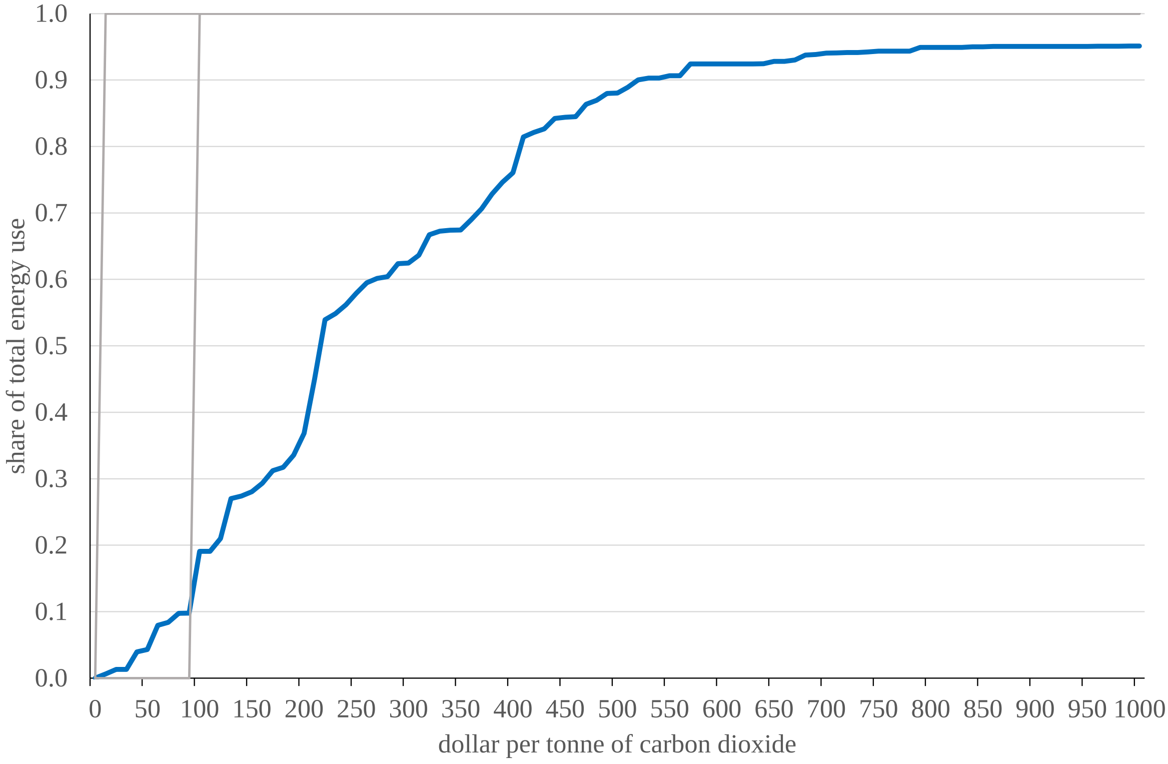

Figure 1. The cumulative histogram of the private benefit of carbon, in 2010 US dollars per tonne of carbon dioxide, per user, fuel and country, weighted by the final energy use. Two illustrative estimates of the social cost of carbon (\$10/tCO$_2$, \$100/tCO$_2$) are marked.

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Supplementary information All pertinent data and computations can be found in endusprice.xlsx

Acknowledgements Marcel Crok and Bjorn Lomborg had excellent comments on an earlier version. Ani Rudra Silwal provided expert research assistance.