Are Carbon Taxes Effective in Mitigating Emissions? Evidence from the EU

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Climate change is possibly the defining issue of our time[1] and has significant economic and societal impact. Shifting weather patterns impact human health, agriculture and food security, water supply, transportation, energy, ecosystems, and others—and are expected to become increasingly disruptive in the coming decades.[2] Globally, governments and regulators are increasingly taking action to try to mitigate climate change. In 2015, 196 countries agreed to the adoption of the Paris Agreement, which was signed at the UN Climate Change Conference (COP21) in Paris, France. The Paris Agreement mandates limiting greenhouse gas emissions (GHGs) with a goal of reaching peak emissions before 2025 and then declining by 43% by 2030.[3]

Changes mandated by the Paris Agreement will affect all aspects of society, and business activities are a key to reducing GHG emissions. Investors are increasingly asking for information related to corporate environmental, social, and governance (ESG) metrics in corporate disclosures.[4] Investment firms including Black Rock, the world's largest asset manager with over $10 trillion in assets under management in 2022, state that they believe that climate risk is investment risk. In response to growing demand for metrics related to climate change, standard setters in Europe such as the new International Sustainability Standards Board (ISSB) and the European Banking Authority (EBA) are developing new climate disclosure requirements aimed at helping users to better assess business risks associated with climate change. The SEC in the United States has also proposed new disclosure rules for corporate carbon emissions.

The growing awareness of the risks associated with climate change by investors, regulators, and the general public are motivating increased demand for policies and regulations that will

[1] https://www.un.org/en/global-issues/climate-change
[2] https://www.globalchange.gov/climate-change/impacts-society
[3] https://unfccc.int/process-and-meetings/the-paris-agreement
[4] https://news.gallup.com/poll/389780/investors-stand-esg-investing.aspx

reduce carbon emissions. A key policy initiative is the use of carbon taxes. The linkage between climate change initiatives, policy to motivate corporate actions, and corporate taxation is therefore an important research topic in accounting, and both academicians and commentators have called for more research on this relationship (Hoi, Wu, & Zhang, 2013; Hanlon & Heitzman, 2010; Sikka, 2010). A key environmental issue is corporate greenhouse gas (GHG) emissions.[5] Because businesses are responsible for a majority of such emissions (World Resources Institute, 2004), policy initiatives often are focused on motivating reductions in business GHG emissions, and carbon taxes are a key policy issue.

While there have been modeling studies that predict the theoretical impact of energy taxation (see e.g., Fang, Tian, Fu, & Sun, 2013; Fakoya, 2013; Bovenberg & Goulder, 1997; Goulder, 1995; Li & Lin, 2013; Parry & Williams, 1999), scant research has examined the empirical relationship between energy taxation and actual greenhouse gas emissions (Sumner, Bird, & Smith, 2009). Further, research has not addressed how energy taxation is related to the choice of different emission reduction strategies. Emissions may be reduced through *efficiency* initiatives whereby entities take actions to use less fuel per unit of output, and/or through *effectiveness* initiatives whereby entities seek to use fuels with lower carbon content. We examined the relationship between energy taxation and carbon emissions in the EU from 2011-2019. These dates cover a period of time from when the ETS entered phase 3 implementation but prior to the economic upheaval of 2020 caused by the COVID pandemic. While both energy taxation and the ETS provide incentives for entities to reduce their emissions, the incentives may have

[5] The reduction of GHG emissions is a key policy issue because of their impact on climate and the related economic and ecological changes that scientists predict. The United Nations Intergovernmental Panel on Climate Change (IPCC) concluded that the use of fossil fuels with the resultant GHG emissions is, with more than a 90% probability, the primary cause of climate change (IPCC, 2007). There is a widespread belief that global climate change, if left unchecked, will have significant impact on people and the ecosystems that support them (see e.g., EIA, 2008). This has led to a focus on the economic importance of developing policies to reduce GHG emissions, thereby preventing or reducing climate change (Stern, 2007). Particular emphasis has been placed on reducing CO_2 emissions, with the ultimate goal of stabilizing atmospheric GHG concentrations (Aldy, Ley, & Parry, 2008).

differential impacts. Initially, the market for carbon certificates was not well-established, and the incentive to quickly reduce carbon emissions below a ceiling imposed by the ETS may have motivated short-term strategies; such strategies may have initially been confounded with the incentive to continually lower taxes. Now in Phase 3 implementation, the ETS certificate prices remain low, fluctuating in a narrow range between EUR 6.20 and EUR 6.40 (Abdel-Ati, 2020), and are stable. We examine data on the relationship between carbon and carbon emissions during a period in which no additional changes to the ETS have been mandated and the implementation of ETS policies has remained stable. Further, current policy decision-making about carbon taxes and emissions should be informed by recent data

Energy Taxation and Policy

Tax policy has at its core at least one or both of two objectives: (1) generation of revenue for the government, and (2) motivation of taxpayer behavior for social or economic purposes. Taxes, when implemented effectively, can be a powerful economic incentive and are an important policy tool available to governments to motivate behavior (Dickson, 2007). Nations have implemented emissions taxes to incentivize reductions in GHG emissions since at least 1990, when Scandinavian countries levied energy taxes that focused on gasoline, coal, and natural gas (Elkins, 1999). One form of environmental taxation imposes a charge on GHG emissions. Emissions taxes create incentives because they increase the cost of emissions-intensive goods, thereby increasing the selling price and/or reducing the profit margin on the goods (Baranzini, Goldemberg, & Speck, 2000), which creates a competitive advantage for those who reduce emissions. Theoretically, an emissions tax should: (1) reduce the demand for energy because of the price increase caused by the tax, and (2) motivate a substitution effect that leads to an increased demand for sources of energy with lower emissions.

While energy taxation may apply to any GHG, the majority of energy taxes target carbon emissions because carbon dioxide has the greatest impact on climate change (Elkins, 1999) and is the largest component of GHG, accounting for approximately 82% of GHG emissions from developed countries (UNEP 1999). A carbon tax levies a charge on each unit of CO_2 emitted that is subject to the tax. For instance, the tax may be levied for each unit of CO_2 emitted for each ton of carbon contained in a fossil fuel that is either consumed or sold (Tietenberg & Lewis, 2010). The tax increases the cost of the fuel to reflect the amount of CO_2 emitted. The direct effect of such a tax should motivate improvements in energy *efficiency* so that less energy is used for a given level of production (Bruvoll & Larsen, 2004). The carbon tax increases the unit cost of fuel used, thereby increasing unit production costs. Increased production costs either must increase the price charged for the goods or else reduce the profit margin on goods. Changing price structures impact the competitive position of goods and services within and across companies. For products with a small profit margin, introduction of a carbon tax into the production cost function even may cause some production to become unprofitable and to be eliminated. Further, firms with high emissions will find themselves at a competitive disadvantage relative to firms that create less pollution, pay lower taxes, and thus have lower production costs.

The imposition of a carbon tax should also increases the demand for energy sources with lower carbon emissions per unit of power and motivate a substitution effect so that energy sources that produce fewer emissions are substituted for those with higher emissions. Increased demand for energy sources that produce lower emissions should create incentives for the development of more *effective* energy sources and technologies that produce lower emissions per unit of energy, and should spur business investment to develop and use alternative low-carbon fuels and technologies.

Harrison (2010) notes that carbon taxes are easy to implement in that they can build on an existing tax system. Because an infrastructure for taxation is already in place, monitoring and enforcement costs should be minimized. Carbon taxes should also be relatively predictable (Harrison, 2010). Because the purpose of an incentive-based system is to internalize environmental costs so that they are incorporated into the decision making process of producers and users, predictability of costs has the potential to improve decisions. Further, energy taxes can be imposed on both large and small polluters. Greater transparency with respect to emissions may result because the amount of the carbon tax, if material, would be reported in the firms' financial statements. A carbon tax should therefore provide the incentive for each user subject to the tax to reduce its carbon emissions up to the point that, at the margin, the cost of reducing emissions equals the amount of the tax that is avoided.

Economic theory indicates that all users should face a constant tax rate on carbon use so that the cost of emissions reduction across firms should be equalized; this would satisfy the condition for maximal cost-effectiveness (Goulder, 2009). In theory, the tax rate on carbon should be set to equal the marginal harm from emissions (Metcalf & Weisbach, 2009), and the tax should be equal across sectors and countries as the marginal damage is independent of the location of the emission source (Bye & Bruvoll, 2008).

However, both the appropriate discount rate and the cost of harm from emissions are difficult to estimate (Nordhaus, 2011), and in practice, the tax rate varies both across and within countries, and over time; carbon tax rates vary such that the average price of a ton of carbon is significantly different across countries (Baranzini et al., 2000). Some fuels, such as gasoline and diesel products, have borne high taxes because they have low demand elasticities and can be strong sources of tax revenue (Baranzini et al., 2000). In some instances, significant resistance to the imposition of carbon taxes has led to relatively low tax rates, has made raising rates difficult, and has resulted in exemptions for many energy-intensive firms and sectors (Elkins & Barker, 2001). Throughout Europe, a relatively low implicit carbon tax has traditionally been applied to coal, and Baron (1997) noted that fossil fuels with higher carbon content have often been subject to lower tax rates than those of more carbon-efficient fuels. Additionally, large emission-intensive sectors have been exempted or subject to reduced rates or other tax breaks (OECD, 2004), and competitive pressures have frequently caused policy makers to give exemptions to sectors that would have faced restructuring and downsizing, while sectors with minimal emissions tend to face the highest rates (Bruvoll & Larsen, 2004). To the extent that the tax rate may vary across jurisdictions, there may be incentives for companies to move their production facilities to avoid or minimize energy taxes as opposed to minimizing emissions. The measurement issues with respect to cost of environmental damage make determination of an appropriate rate problematic, and adjusting the rate as new information becomes available is important if the tax is to be optimally effective (Metcalf & Weisbach, 2009). Further, even when tax rates are adjusted, the size and direction of the change in rates may reflect political choices about taxation rather than an attempt to optimize the tax rate relative to the desired policy outcomes.

These variations in the implementation of the taxes and the tax rate potentially threaten the effectiveness of tax policy in incentivizing reductions in emissions, and make it difficult to evaluate the results of carbon tax policies. While some studies have shown that energy taxes implemented in the 1990s may theoretically have reduced overall emissions by as much as 15%, estimating the true impact of carbon tax policies from these studies is challenging as estimates were largely conducted using simulation modeling and generally did not consider the impact of other carbon mitigation policies (Sumner, Bird, & Smith, 2009), making it important to empirically test the policy initiatives.

While theory predicts that that carbon taxation and CO_2 emissions should be inversely related, this relationship depends on the tax being higher than the cost of pollution abatement. Given the political resistance to energy taxes, the number of exemptions to such taxes, and the difficulty in determining the optimal tax, the effectiveness of an energy tax policy cannot be assumed. Therefore, we evaluate the association between energy taxes and the intensity of overall CO_2 emissions in the EU.

In our study, we focused on a particular measure of CO_2 emissions, *overall carbon intensity*, which is defined as metric tons of carbon dioxide per monetary unit of activity. Further, overall carbon intensity can be decomposed into (1) *carbon intensity of the energy supply*, which is the total carbon content of energy used, and (2) *energy intensity*, which is total energy consumption per unit of Gross Domestic Product.

Overall Carbon Intensity

We tested to see if there is an inverse relationship between energy taxation and overall carbon intensity, and we found a significant inverse relationship between the implicit tax rate on energy and overall carbon intensity ($p < 0.01$). Specifically, a 1% increase in the implicit tax rate on energy is associated with a decrease in overall carbon intensity of approximately 0.18 %.

Carbon Intensity of the Energy Supply

We expected an inverse relationship between energy taxation and the carbon intensity of the energy supply, but we did not find a significant inverse relationship between the implicit tax rate on energy and carbon intensity of the energy supply ($p = 0.4392$).

Energy Intensity

We also expected an inverse relationship between energy taxation and energy intensity. Our analysis confirmed this expectation, and we found a significant inverse relationship between *ITRE* and *ENI* ($p < 0.01$). Specifically, a 1% increase in the implicit tax rate on energy is associated with a decrease in energy intensity of approximately 0.28%.

Discussion of Results

Our results demonstrate that there is a significant between carbon taxes and CO_s emissions, indicating that carbon taxes are a potentially meaningful policy initiative. Overall, our results are consistent with energy taxes having a significant effect on CO_2. However, when overall carbon intensity is broken down into two component parts relating to effectiveness (carbon intensity of the energy supply) and efficiency (energy efficiency), we find that energy taxes have a significant impact on efficiency, but not effectiveness. This is a concern as energy effectiveness, whereby fuels with lower carbon contents are used, generally requires medium- and long-term initiatives if policy goals are to be met (MCCC, 2009).

The significant relationship between the implicit tax rate on energy and energy intensity is important because energy efficiency, whereby less fuel is used per unit of output, can often be accomplished with immediate conservation measures such as better temperature control and reducing waste. Longer-term reductions may be realized by actions such reengineering manufacturing processes to use equipment that is more efficient. Further reductions can be realized by such things as upgrading heating and cooling equipment; temperature control may account for 38% of a building's energy usage (Gonzalez-Torres, Perez-Lombard, Coronel, Maestre, and Yan, 2022). HVAC systems more than 10 years old are generally significantly less efficient than newer systems.

However, while these initiatives are important, they are inadequate to meet long-term policy goals that necessitate the development of low-carbon energy sources. Continued economic growth requires increased energy usage, and long-term reduction of carbon emissions requires the development of energy sources with lower carbon content. While other policy initiatives may be motivating increased investment in low-carbon energy sources, the non-signification relationship between our effectiveness metric and carbon emissions indicates that carbon tax do not currently appear to be motivating these investments.

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